THE POWER OF FORGOTTEN OPINIONS:
WHY AN ORGANIZATION CHOOSES INACTION OVER THE PUBLIC'S SAFETY

Junko Shimazoe

A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Sociology.

Chapel Hill
2012

Approved by:

Howard E. Aldrich

Kenneth T. Andrews

Richard M. Burton

Scott F. Rockart

Harvey M. Sapolsky

Catherine Zimmer

ABSTRACT

JUNKO SHIMAZOE: The Power of Forgotten Opinions:
Why an Organization Chooses Inaction over the Public's Safety
(Under the direction of Howard E. Aldrich)

This dissertation aims to explain why organizations and their members cannot prevent large-scale accidents even when there is prior information concerning a problem. Large-scale accidents, which are also called "organizational accidents", are low-probability events, but once they occur, the outcomes are disastrous both in and out of an organization. However, due to their rarity and specific characteristics, few organization theories explain in a simple, straightforward manner how members' choices lead to organizational-level decisions that cause such accidents. This shortcoming is conspicuous with respect to members' decisions in a "gray zone", in which no clear crises or threats to organizational goals and performance are present.

In this dissertation, I explain the relationship between members' choices and organizational-level decisions in a "gray zone" rather than organizational preparedness for, and responses to, accidents or crises. For this purpose, I draw on theories on social psychology, organizational cognition, and group behaviors and utilize multi-level models and agent-based simulation. The particular focus of this dissertation is how differences in organizational conditions surrounding speaking up on and taking action against potential problems change members' and organizational decisions.

This dissertation clarifies that organizational choices of action or inaction depend on the opinions of members who are detached from the discussions of potential problems. The detached members include non-experts, members with higher power and status, and those with more or fewer peers, depending on organizational conditions. In addition, as organizational conditions become less favorable to speaking up and taking action, the opinions of the detached are more likely to prevent members from reaching a consensus on what to do. In a "gray zone", in which a clear threat to organizational performance has not emerged yet, the opinions of the detached members tend to be left unheard or forgotten. When these forgotten opinions favor inaction against potential problems, it is more likely that organizations do nothing and the inaction eventually leads to rare but salient events.

ACKNOWLEDGMENTS

First, I am thankful to the committee members for their continuing support. Howard Aldrich, who was my adviser and the committee chair, guided me through years of the doctorate education and the dissertation process. Kenneth Andrews showed me the excitement of studying organizations in this world. I owed Richard Burton many thanks, including his encouragement of my interest in computational organizational studies. Scott Rockart showed tremendous dedication to make this dissertation doable, especially in terms of modeling and experiments. Without his instruction and guidance, this dissertation was impossible. Harvey Sapolsky provided invaluable advice from the perspective outside of sociology. Cathy Zimmer extended her big heart and helped me to go though the dissertation process as well as make numbers from the simulation accessible to readers. Thanks to their commitment, I could complete this dissertation.

Second, outside of the committee, I would like to express my thanks to Claus Rerup of Richard Ivey School of Business, University of Western Ontario. He kindly provided a copy of his paper on the "gray zone", which was one of the essential concepts of this dissertation.

Third, among the friends on the other side of the Pacific, I would especially like to thank Bruce Stronach. His advice from international experience in the US and Japanese institutes of higher education was always valuable at every stage of academic, career, and professional development.

Finally, the family was always a crucial source of encouragement. My mother, Ikuko, and members of the extended family always reminded me where I belonged while enjoying the freedom to explore the fun of graduate studies.

TABLE OF CONTENTS

LIST OF TABLES

Table

LIST OF FIGURES

Figure

LIST OF ABBREVIATIONS

ABM	agent-based model
ABS	agent-based simulation
BP	British Petroleum
CIA	Central Intelligent Agency
FAA	Federal Aviation Administration
FBI	Federal Bureau of Investigation
HRO	high-reliability organization
KAL	Korean Airlines
NASA	National Aeronautics and Space Administration
Pan Am	Pan American Airlines
PAL	Philippine Airlines
TPS	team psychological safety
TWA	Trans World Airlines

LIST OF SYMBOLS

AO_i	an agent's opinion value after a round of interactions
$B(1, \beta)$	a binomial distribution of agents' match of expertise to potential problems
CI	the number of counterparts
ci	an index for a counterpart
E_{ci}	match between a counterpart's expertise and the field of potential problems
E_i	match between an agent's expertise and the field of potential problems
i	an index for an agent or a member
$I = sN\text{^}p$	the psychosocial law
I	the total amount of social impact
I_{ci}	a counterpart's influence over an agent
IO_{ci}	the impact of a counterpart's opinion value
IO_i	the impact of an agent's opinion value
j_{ci}	a counterpart's order of interaction with an agent
k	a scaling constant to measure physical strength in the psychophysical law
N	the number of others that a target encounters in the psychosocial law
O	agents' opinions
O_{ci}	a counterpart's opinion value
O_i	an agent's opinion value before a round of interactions
p	a power in the psychosocial law
PS_{ci}	a counterpart's power and status
PS_f	agents' formal power and status

PS_{fi}	an agent's formal power and status
PS_i	an agent's power and status
PS_{inf}	agents' informal power and status
PS_{infi}	an agent's informal power and status
R_{ci}	j^{th} order of a counterpart's interaction with an agent
s	a scaling constant of social impact in the psychosocial law
$U(-1, 1)$	a uniform distribution of agents' opinions
x	the order of hierarchical ranks in an organization
α	definition of how the number of agents decreases as hierarchical stages become higher
β	the parameter of the probability that an agent has the value of 1, that is, its expertise matches the field of potential problems.
γ	a power in the psychophysical law
ζ	the parameter that defines the curve of counterparts' influence on an agent's opinion
Φ	an actual magnitude of physical strength in the psychophysical law
$\Psi = k\Phi\text{^}\gamma$	the psychophysical law
Ψ	a subjective evaluation of physical strength in the psychophysical law

CHAPTER 1

INTRODUCTION

Rare but salient events catch researchers' attention; however, among the diverse topics in organizational studies, those events have not become mainstream. There are a few reasons for this limitation. First, the sample size of these events is small; thus, parametric statistical analyses are not relevant (March, Sproull and Tamuz 1996). Second, being rare means that the conditions surrounding the events tend to be peculiar to each case. Therefore, it is difficult to determine common causes that are useful for preventing such events (March, Sproull and Tamuz 1996), although case studies provide valuable insights into the causes of specific events. Third, because the events are rare, their contribution to improvements in day-to-day organizational performance is limited, whereas organizational studies are biased toward successes (Argote 2005; Denrell 2003; Rerup 2006; Weick, Sutcliffe and Obstfeld 1999). The financial crisis in 2008 has kindled concerns about rare but salient events in management studies (e.g., Harvard Business Review 2011; Taleb 2007), and there have been calls for studies on "gray areas" (Rerup 2006) that are not clearly successes or failures (Rerup 2006; Rerup 2009; Sitkin 1992; Weick 1984). However, the main question of organizational studies is how an organization can be successful so that managers can efficiently learn from successful cases (e.g., Hamel and Breen 2007; McShane and Von Glinow 2005; Weick and Sutcliffe 2007).

This drive toward successful organizational performance is quite strong. It motivates researchers even if their articles are about, for example, "difficulties" in turning knowledge

into action (Pfeffer and Sutton 2000), "problem" fixing (Repenning and Sterman 2001), "uncertainty" (Milliken 1987; Sitkin, Sutcliffe and Schroeder 1994; Thompson 1967), "failures" (Cannon and Edmondson 2001; Cannon and Edmondson 2005), "threat" (Staw, Sandelands and Dutton 1981), and "crises" (Weick 1988). Under the shadow of this strong drive, rare but salient events are considered marginal occurrences that do not deserve massive efforts to study them in detail.

This limited interest in rare but salient events, however, has created a weakness in the rich field of organizational studies. For example, when one attempts to find common causes of "organizational accidents" (Reason 1990; Reason 1995a; Reason 1995b) from existing insights in organizational studies, s/he simply finds a patchwork of theories on organizational learning, high-reliability organizations, normal accidents, social psychology in organizations, and findings from various qualitative case studies. Each of the theories and studies provides possible explanations for various organizational accidents, but they do not add up to a systematic, clear, and straightforward explanation of "the nature of causal relationships" (Sutton and Staw 1995) of rare but salient events that organizational studies can specifically propose.

This dissertation is an effort that may eventually lead to a solution to the above weakness in the field of organizational studies. I do not claim that this dissertation provides *the* solution to the weakness, but it is motivated by the belief that rare but salient events, such as organizational accidents, can be explained in a more straightforward manner by drawing on wisdom in the field of organizational studies. In addition, because organizations are major social actors in which people's lives are embedded (Aldrich 1979) and scholars in the field cannot disregard rare but salient events, attempts to solve the problem of the field's weakness

are worthwhile. I therefore explore conditions under which inaction at the organizational level emerges from members' interactions during ordinary and routine days using an agent-based simulation (ABS).

With regard to rare but salient events, such as organizational accidents, academic studies and investigation reports describe that some members observe a potential problem and discuss necessary actions but that no action is taken at the organizational level (e.g., Beck 1979; BP Investigation Team 2005; Casamayou 1993; Columbia Accident Investigation Board 2003; Gioia 1992; Hopkins 2010; Janis 1972; Janis 1983; Mahler 2009; National Commission on Terrorist Attacks upon the United States 2004; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011; Presidential Commission on the Space Shuttle Challenger Accident 1986; Schwartz 1990-1991; Starbuck and Farjoun 2005; Starbuck and Milliken 1988; Stoss and Fabian 1998; The BP US Refineries Independent Safety Review Panel 2007; Vaughan 1996). This dissertation does not focus on whether those who observe a problem are satisfied with organizational inaction. On the contrary, it considers why an organization behaviorally seems to choose inaction in spite of members' recognition and discussions of potential problems. Under what conditions does a choice of organizational inaction emerge? Under what conditions is a choice of action made? By answering these questions, I formulate propositions on how organizational inaction emerges from members' interactions during ordinary and routine days. Then, I discuss why rare but salient events such as organizational accidents occur from the point of view of organizational studies.

There are four limiting conditions in this dissertation. First, this dissertation does not focus on inaction at the individual level. At the individual level, members may discuss

potential problems and even blow a whistle inside their organization. As the reports and studies on rare but salient events suggest, individuals' actions do not surface as changes at the organizational level. Then, why do outcomes at the organizational level differ from occurrences at the individual level? This dissertation considers why behaviors and choices at these two levels seem to be uncorrelated. Besides, I do not discuss "bad apples", psychopaths, or criminal behaviors in organizations. In this dissertation, I investigate why even an organization that consists of carefully selected, diligent, educated, and committed members does not seem to take action although its members acknowledge a potential problem.

Second, this dissertation focuses not on organizational types but on situations that members encounter in their organization. Different types of organizations, such as government agencies, private companies, and public and private universities, may have different degrees of members' interactions on a daily basis. However, the reports and studies on rare but salient events suggest that regardless of sectors and organizational types, members communicate their concerns about potential problems to colleagues. In this regard, situations, not places, are assumed to determine members' behaviors.

Third, this dissertation does not focus on organizational performance in terms of making profits or completing goals day by day. Inaction at the organizational level becomes a great concern when it causes damage to the public's life and safety, as is the case with organizational accidents. It is especially dismaying when members identify potential problems but no changes are made at the organizational level, and as a result, a large-scale accident occurs and harms people outside of the organization. These people have no say in the organization's plan and policy, but they are victimized by its inaction.

Finally and most importantly, this dissertation does not focus on members' interactions during rare but salient events. Rather, it focuses on their interactions during ordinary and routine days, long before dangers start looming and become clear. As I explain in Chapter 2, why a rare but salient event occurs is a different question from what an organization learns from it or how an organization handles it. The latter two questions concern organizational responses to existing problems, but the former concerns organizational decision-making that causes the problems. In Chapters 2 and 3, I show that findings from qualitative case studies on rare but salient events (e.g., Snook 2000; Vaughan 1996), as well as investigation reports, suggest that the root causes of such events evolve during ordinary, peaceful days long before members are thrown into "high-velocity situations". To explain the causes of rare but salient events from an organizational point of view, it is necessary to focus on how members interact during usual days and how their interactions generate inaction (or action) at the organizational level over time.

This dissertation is structured as follows. In Chapter 2, I describe problems of existing organizational studies in exploring the nature of causal relationships between rare but salient events and organizational decision-making. After clarifying the differences between rare but salient events and high-velocity situations, I discuss various subfields of organizational studies, from organizational learning to qualitative case studies and explain why existing studies do not identify organizational decisions that cause rare but salient events. Then, in Chapter 3, I explain what is necessary to solve this weakness, including why an ABS is useful for this purpose. In this chapter, I also review the social psychology literature that provides insights on relationships between members' interactions and organizational-level outcomes. The literature reviewed here constitutes the bases for agent-based models

(ABMs) in this dissertation. In Chapter 4, I perform controlled experiments with the minimalist ABMs. Then, in Chapter 5, the ABMs are expanded into larger models for thought experiments. The last chapter, Chapter 6, presents the discussions and conclusion. In this chapter, I summarize the findings of this dissertation, make propositions about organizational causes of rare but salient events, and discuss the implications of these propositions from the perspective of organizational studies. The chapter also presents plans for future research.

CHAPTER 2

A MISSING PIECE IN A JIGSAW PUZZLE – ORGANIZATIONAL DECISION-MAKING THAT CAUSES RARE BUT SALIENT EVENTS

In this chapter, I describe why existing organizational studies do not add up as explanations of the causal relationships between organizational decision-making and rare but salient events. First, I define rare but salient events and high-velocity situations. The classification of these two concepts is essential to highlight problems in the subfields of organizational studies. Then, I describe problems in the existing research by reviewing the subfields of (1) organizational learning, (2) high-reliability organizations, (3) normal accidents, (4) qualitative case studies on organizational accidents, and (5) social psychological studies.

Definition of Rare but Salient Events

To understand existing organizational studies' problems in explaining rare but salient events, it is important to clearly define rare but salient events and high-velocity situations.

Rare but salient events in organizational studies have two aspects: frequency and impact. Roughly stated, frequency can be called a quantitative aspect of rare but salient events and impact can be called a qualitative aspect of such events. Quantitatively, "rare" indicates statistical infrequency, i.e., (1) sample sizes are small, and/or (2) samples are extreme outliers in normal distributions (Lampel, Shamsie and Shapira 2009; March, Sproull and Tamuz 1996). The probability that rare but salient events occur is extremely low, and

even if they occur once, they may not repeat again (Maitlis and Sonenshein 2010; Perrow 1999; Weick, Sutcliffe and Obstfeld 1999). Thus, studies of rare but salient events assume that the probabilities are calculable and that because of the infrequencies, the risk is extremely small.

A risk is measurable as the probability distribution of outcomes of given alternatives (Ballesteros 2007; Farber 2010; Gilboa 2009; Knight 1921; March and Simon 1958). Because of the calculable probabilities, an individual can compare the alternatives and make a choice following his/her preferences (Gilboa 2009; Knight 1921; March and Simon 1958). Although psychological experiments show that human choices do not follow the probability distributions in an orderly manner (e.g., Brockner 1992; Kahneman and Tversky 1979; Kahneman and Tversky 1984; Ross and Staw 1986; Schoorman and Holahan 1996; Staw 1976; Staw and Fox 1977; Tversky and Kahneman 1981; Tversky and Kahneman 1992), if the probability of a payoff is quite small, the choice that leads to the payoff does not typically deserve serious consideration or, at least, is not a priority for consideration. In short, for the aspect of frequency, the words "rare but salient events" connote extremely small and, thus, negligible risks in the eyes of decision-makers.

However, the statistical infrequency and negligible risks disguise the importance of rare but salient events to organizations and society. It is necessary to pay attention to another aspect of such events, the aspect of impact. Impact concerns the qualitative characteristics of rare but salient events, which are unusual, challenging, uncertain, surprising, and consequential. Rare but salient events are extraordinary and do not have similar occurrences from which to make inferences about choices and their outcomes (Beck and Plowman 2009; Lampel, Shamsie and Shapira 2009; Rerup 2009). Thus, these events pose challenges to

organizational survival (Beck and Plowman 2009; Maitlis and Sonenshein 2010; Rerup 2009), generating a sense of crisis and uncertainty (Maitlis and Sonenshein 2010; Rerup 2009; Starbuck 2009). When situations seem to be uncertain, it is difficult to define probability distributions of outcomes because the events that lead to those situations may be unique (Ballesteros 2007; Farber 2010; Gilboa 2009; Knight 1921; March and Simon 1958). It is difficult to identify the controllable and uncontrollable factors of the events (Knight 1921; Maitlis and Sonenshein 2010) and to order choices according to preferences (Farber 2010; Gilboa 2009; March and Simon 1958). These difficulties that rare but salient events bring to organizations are one reason why researchers cannot disregard them.

In addition, rare but salient events may be unforeseeable and unexpected (Taleb 2007), in other words, they are surprises to organizations (Weick, Sutcliffe and Obstfeld 1999). They are unexpected and surprising because they are statistically infrequent, and their impact on organizations and society may be substantial (Lampel, Shamsie and Shapira 2009; Madsen 2009; Perrow 1999; Taleb 2007), such as various organizational accidents (e.g., Birkland 2004; Bragg 2007; Haunschild and Sullivan 2002; Lampel, Shamsie and Shapira 2009; Perrow 1999; Weick 1990). In this regard, rare events are "low-probability and high-consequence" events (Maitlis and Sonenshein 2010; The Royal Society 1992) to organizations and society. As a result, such events are quite salient and capture the interest of both researchers and the public despite their rarity (Ballesteros 2007; Lampel, Shamsie and Shapira 2009; Perrow 1999).

The above characteristics of rare but salient events are partially explicable from the quantitative point of view. Some of the characteristics originate from the statistical rarity of the events. In addition, the magnitude of their consequences is quantitatively measurable,

such as loss of life and damage to property. Concerning uncertainty, it is argued that examining heavy and/or fat tails of normal distributions and studying phenomena that follow power-law distributions are difficult (Clauset, Shalizi and Newman 2009; Farber 2010; Gilboa 2009; Mitzenmacher 2003). However, these difficulties are also problems in existing statistical and other research techniques. Therefore, I have called the aspect of impact the only "roughly" qualitative aspect of rare but salient events. In terms of statistically calculable risks, the infrequency of rare but salient events renders negligible risks, but the costs justify attention to such events. The impact of these events, when they become topics of organizational studies, extends beyond number crunching. Rare events become salient and catch researchers' attention because of their negative qualitative characteristics, such as uncontrollability, challenges and difficulties that they pose on organizational decision-making and survival, interest of the public that may negatively affect organizations, and most importantly, negative consequences to the public including, but not limited to, monetary losses and damages to health and life.

In the study of rare but salient events and organizational decision-making, two factors are worth noting. First, because of the uncertainty accompanying these events, theories on individual decision-making, especially those on risk calculations by individuals, are not sufficient to explain why organizations seem to make a decision that may lead to such events. Regardless of whether the theories are based on the rational-choice model (e.g., Becker 1976; Gilboa 2009) or the model of bounded rationality (e.g., Ariely 2009; Ashforth and Anand 2003; Bragger et al. 1998; Bröder and Schiffer 2006; Gigerenzer, Czeslinski and Martignon 1999; Meyer 2006; Simon 1955; Sitkin and Pablo 1992; Staw 1976; Tversky and Kahneman 1974), they concern foreseeable and statistically calculable risks. These theories may predict

the behavior of individual members of an organization; however, the uncertain characteristics of rare but salient events leave something inexplicable with the theories (e.g., Taleb 2007), especially in regard to how organizational-level choices are made. Second, it is necessary to distinguish rare but salient events from high-velocity situations. I define high-velocity situations and explain the necessity in the next section.

Definition of High-Velocity Situations

Rare but salient events and high-velocity situations overlap in some cases, but they are often not the same. To explore the relationship between rare but salient events and organizational decision-making, it is necessary to clarify when such events and high-velocity situations overlap and when they do not.

In organizational studies, the term "high velocity" is used to describe an organizational environment in which markets and industries are dynamic and full of uncertainty (e.g., Bourgeois III and Eisenhardt 1988). However, the concept is also helpful in describing situations that organization members experience when they encounter rare but salient events. Therefore, similar ideas repeatedly appear in the existing research on rare but salient events (e.g., Christianson et al. 2009; Comfort, Ko and Zagorecki 2004; Maitlis and Sonenshein 2010). Paradoxically, the usage of the ideas causes confusion in this research. Thus, I attempt to distinguish rare but salient events from high-velocity situations while borrowing the term "high velocity". For this task, I first explain high-velocity situations. Then, I discuss the cases for which they differ from rare but salient events.

When an organizational environment is called high-velocity, dynamic and uncertain conditions in the environment determine the organizations' challenges and required actions. Organizations face changes in actors, demand, technology, and regulations, which are not

only rapid but also abrupt, non-linear, and unpredictable (Bourgeois III and Eisenhardt 1988; Eisenhardt 1989b; Eisenhardt and Bourgeois III 1988; Eisenhardt and Martin 2000). These changes are exogenous to organizations and create tremendous stress on organizational strategy because delays and mistakes in responses are costly and recoveries from them are difficult (Bourgeois III and Eisenhardt 1988; Eisenhardt 1989b). In addition to the turbulent, unstable conditions (Eisenhardt and Martin 2000; Forbes 2007), organizations face difficulties in obtaining accurate information about the situation (Bourgeois III and Eisenhardt 1988; Eisenhardt 1989b; Eisenhardt and Bourgeois III 1988). As a result, it becomes difficult to predict the outcomes of their strategic decisions (Eisenhardt and Martin 2000). This uncertainty may be amplified by the responses of other organizations in the same markets and industries (Nadkarni and Narayanan 2007).

To be successful in the environment, organizations must make decisions quickly and continuously respond to changes and feedback on their decisions from one situation to another by creating knowledge that is relevant to specific situations (Bourgeois III and Eisenhardt 1988; Eisenhardt and Bourgeois III 1988; Eisenhardt and Martin 2000). In other words, organizations must strategically utilize “small losses” or “intelligent failures” (Cannon and Edmondson 2005; Sitkin 1992) and “small wins” (Weick 1984) to mitigate negative effects of feedback under uncertainty. These processes may be considered opportunities for quick organizational learning (Eisenhardt and Martin 2000) if organizations fine-tune their strategies as quickly as possible and successfully survive in the environment.

The above conditions and stresses are similar to those that organization members face during rare but salient events. Similar ideas even appear in the definition of rare but salient events, especially in its aspect of impact, such as challenging, uncertain, surprising, and

consequential. Because of these similarities, organizational studies on rare but salient events, such as those on organizational accidents, describe the situations that the events create using ideas that are similar to those of high-velocity environments. For example, when the events are occurring, situations are "rapidly evolving" (Christianson et al. 2009; Comfort, Ko and Zagorecki 2004), changes and crises are "emerging" and "unfolding", "decisions are to be made swiftly" (Christianson et al. 2009; Maitlis and Sonenshein 2010; Weick, Sutcliffe and Obstfeld 1999), niches are "rapidly opening and closing" (Vogus and Welbourne 2003), and the events are full of "surprises in the moment" (Weick, Sutcliffe and Obstfeld 1999). These descriptions convey confusing and stressful situations that organization members face while handling rare but salient events.

In detail, the situations are as follows. First, quick decisions and responses to on-going changes and incoming information are necessary. Second, the sense of uncontrollability and unpredictability is strong because the situation becomes clear only piece by piece as feedback on the decisions and responses based on the limited information. Third, it is unclear when and how the situations will end. Fourth, mistakes in the decisions and responses result in substantial negative outcomes. Therefore, the margins of error in the decisions and responses are extremely small. These are also characteristics of high-velocity situations. The uncertainty of rare but salient events may result in feedback effects that amplify noise and disturb risk calculations, which contributes to the emergence of the situations (Åström and Murray 2008; Farber 2010; Nadkarni and Narayanan 2007).

However, not all rare but salient events coincide with high-velocity situations. There are four possible relationships between these events and situations. First, the events and situations completely overlap. Second, the situations are of high velocity, but rare but salient

events do not follow them. Third, rare but salient events emerge over time from situations that are not of high velocity rather than coinciding with high-velocity situations. Finally, events are not rare and salient and do not involve high-velocity situations. This last possibility is beyond the scope of this dissertation. In the next section, I explain the former three possibilities using the case of 9/11.

Not Always Compatible: Rare but Salient Events and High-Velocity Situations

It is not difficult to imagine rare but salient events coinciding with high-velocity situations. This state exists in the middle of rare but salient events while organization members struggle to understand the situation and attempt to respond to piecemeal information as quickly as possible. In short, the two phenomena of rare but salient events and high-velocity situations are coevolving.

On the morning of September 11, 2001, first responders, such as firefighters, flight controllers, military personnel, and airline operators, among others, faced the co-evolution of the two phenomena. First, the event began with an aircraft crashing into one of the World Trade Center buildings, which was a rare but salient occurrence. Second, the first responders had to rely on the limited information available and could not instantly develop a big-picture understanding of the coordinated terrorist attack (National Commission on Terrorist Attacks upon the United States 2004). Flight controllers and airline operators encountered losses of radio and transponder signals from multiple aircrafts, received confusing communications from the flights, and attempted to understand the meaning of those communications; however, it took time for them to know that it was not a hijack for which they had trained and that more than one plane had been hijacked (National Commission on Terrorist Attacks upon the United States 2004). A Boston flight controller requested the Air Force to scramble fighter

jets, and the Air Force responder first questioned whether it was an exercise or not[1] (National Commission on Terrorist Attacks upon the United States 2004).

Even after the possibility of a coordinated attack with hijacked commercial airliners was considered, confusions remained concerning which flights were in the air and where they were heading (National Commission on Terrorist Attacks upon the United States 2004). While these first responders did as much as they could in the unusual, challenging, uncertain, surprising, and consequential situation, firefighters rushed into the World Trade Center to rescue victims. They did not know that another plane would crash into another tower in less than twenty minutes (National Commission on Terrorist Attacks upon the United States 2004) and that the structure of the towers, which was damaged by the clashes, could not tolerate the high heat caused by massive gallons of burning kerosene (Bazant 2001; The National Institute of Standards and Technology (NIST) 2011).

This co-evolution of rare but salient events and high-velocity situations may be typical of large-scale accidents and disasters, such as 9/11. When one of these incidents occurs, the other unexceptionally accompanies it. However, they may not always coincide. For example, on the same morning of September 11, flight controllers of the Federal Aviation Administration (FAA) landed approximately 4,500 planes, both domestic and incoming, in the US airspace without accidents (Levin, Adams and Morrison 2011). They faced the same high-velocity situation as the first responders in the above paragraphs. Information arrived piece by piece, and no precedents existed to ground all flights to any of

[1] This response by the staff in the Northeast Air Defense Sector might be because the North American Aerospace Defense Command planned an organization-wide exercise in that morning. The 9/11 Commission concluded that the planned exercise did not make military responses slower. The point here is that it was difficult to obtain a full picture of the situation while the event was unfolding. For details, see Notes to Chapter 1 in National Commission on Terrorist Attacks upon the United States. 2004. "The 9/11 Commission Report." Washington, DC.

their nearest airports. Many planes were sitting in those airports because they had been waiting for takeoff, which made the task more complicated. To accommodate all incoming planes, the controllers needed to ask Canadian airports to allow some of them to land, but it was not clear whether Canada accepted planes that were detoured from the US.

In spite of these difficulties, they "flawlessly" (National Commission on Terrorist Attacks upon the United States 2004:31) grounded all airplanes. The flawless execution of the grounding exemplifies that high-velocity situations do not necessarily lead to negative rare but salient events if organization members apply existing routines to unexpected events in a mindful manner, as described in theories of high-reliability organizations (HROs) (e.g., Roberts 1990; Weick and Roberts 1993; Weick, Sutcliffe and Obstfeld 1999). In hindsight, only four planes appeared to be clearly intended to attack targets. Thanks to the FAA flight controllers who may have behaved as theories of HROs dictate, we do not know how many more planes would have been hijacked. We note that only four planes were lost in this unusual situation, and all but the four landed safely.

The above case is a fortunate example in which a high-velocity situation did not lead to a negative rare but salient event. In other cases, rare but salient events may emerge over time from non-high-velocity situations. The same event of 9/11 and the same organization, the FAA, provide an example of such cases. According to the 9/11 Commission, one of the causes of the event was technical issues in passenger screening at airports, such as the insufficient precision and sensitivity of metal detectors to detect small-size blades and the incomplete FAA list of terrorists compared to the lists of the Department of State, FBI, and CIA (National Commission on Terrorist Attacks upon the United States 2004).

However, those technical difficulties had developed and been retained long before 9/11, that is, long before organization members faced this high-velocity situation. Some of the deficiencies might have emerged because of the FAA's long-term organizational learning. Before 9/11, the FAA considered explosives and missiles as major threats to aviation security, not small arms that hijackers might carry (National Commission on Terrorist Attacks upon the United States 2004). No hijacks had occurred in the US during the decade before 9/11, and flight crews were expected to be able to handle hijackers if an incident occurred (National Commission on Terrorist Attacks upon the United States 2004). In contrast, more than several events involving explosives had occurred in and out of the US (National Commission on Terrorist Attacks upon the United States 2004), such as TWA 840 (1986), KAL 858 (1987), Pam Am 103 (1988), Pan Am 830 (1993), and PAL 434 (1994).

In this regard, the FAA seemed to have learned experientially and vicariously from rare but salient events before 9/11 and developed a policy of airport passenger screening that focused on explosives. The FAA's organizational learning is not a topic of interest in this dissertation. Rather, interest lies in the routines at airport security gates, which failed to catch terrorists on September 11, 2001 and had been developing long before the day while situations were not of high velocity.

Passenger screening at airport security gates was "considered the most important and obvious layer of security" (National Commission on Terrorist Attacks upon the United States 2004:84), but the smooth processing of passengers was a major concern of the FAA and air carriers. Small blades, which the FAA understood to be a potential menace to safety, were practically allowed to pass because the increased sensitivity of detectors could worsen congestion at the gates (National Commission on Terrorist Attacks upon the United States

2004). Air carriers, which had executed the screening before 9/11, ignored the FAA's requirements on hand searches of carry-on luggage unless explosives were involved (National Commission on Terrorist Attacks upon the United States 2004). The Inspector General of the Department of Transportation testified before the 9/11 Commission that air carriers had insisted that security should not hamper them from "moving passengers and aircrafts" (National Commission on Terrorist Attacks upon the United States 2004:85). Reports by the Government Accounting Office repeatedly described the poor performance of screening (National Commission on Terrorist Attacks upon the United States 2004). In short, security holes in the screening processes had been left open for a long time while days passed without rare but salient events such as the disaster on September 11, 2001.

Why did the recognition of security holes not lead to changes at the organizational level of the FAA and air carriers? Even if some individuals attempted to correct the problems, the security holes remained open at the organizational level and terrorists exploited the holes on the morning of 9/11 (National Commission on Terrorist Attacks upon the United States 2004).

This example of the passenger screening routines suggests that rare but salient events may emerge over time from non-high-velocity situations. In other words, these events may develop from organization members' behavior during ordinary and routine days long before such events occur. During these days, organization members' performance is not perfect, but they do not encounter disastrous outcomes. Their days are neither a total success nor a total failure, that is, their organization is in a "gray zone" (Argote 2005; Denrell 2003; Rerup 2006).

The interest of this dissertation is what occurs in organizations when organizational inaction in non-high-velocity situations eventually leads to rare but salient events. The first case, in which rare but salient events and high-velocity situations co-evolve, may be a good example to study how organizations respond to and handle such events while they are occurring (e.g., Christianson et al. 2009; Perrow 1999; Sagan 1993; Weick 1993). The second case, in which high-velocity situations do not result in rare but salient events, may provide positive insights on the organizational preparedness needed to prevent rare but salient events, for example, to prevent the situations from becoming more devastating and developing into rare but salient events (e.g., Bigley and Roberts 2001; Roberts 1990; Weick and Roberts 1993; Weick and Sutcliffe 2007; Weick, Sutcliffe and Obstfeld 1999). In the third case, which is the interest of this dissertation, rare but salient events emerge over time from non-high-velocity situations. This case may be helpful in exploring why organizational inaction is common (even if potential problems are recognized) before organizations face clearly devastating outcomes (e.g., Bazerman and Watkins 2004; Fischhoff 2006; Gerstein 2008; National Commission on Terrorist Attacks upon the United States 2004:101, 320; Rerup 2009) and what occurs in those organizations while members interact during ordinary and routine days. Therefore, the case may be helpful in explaining the causes of rare but salient events in terms of organizational decision-making.

The investigation of rare but salient events without attention to differences among these three cases, or phases, of such events may cause confusion in exploring "the nature of causal relationships" (Sutton and Staw 1995) between organizational decision-making and rare but salient events. First, descriptions of the organizational responses to the events may be confused with descriptions of the organizational causes of the events. Second, it is

possible to confuse organizational studies on preventive measures of rare but salient events with those on the causes of the events. Finally, high-velocity situations, i.e., unfolding events, may be confused with potential problems that members encounter during ordinary and routine days long before the situations emerge.

Then, what does the existing research in the field of organizational studies explain about the phases and causes of rare but salient events? What confusion exists in these studies? In the sections below, I review the organizational studies literature and explain its problems in identifying the organizational decision-making that causes rare but salient events.

Problems in Organizational Studies in Exploring Rare but Salient Events

With the term *problems*, I do not imply that existing research is not helpful in providing insights into rare but salient events. Indeed, there is a rich body of literature about such events. For example, studies on organizational learning describe why and how organizations do or do not learn from rare but salient events. Studies on HROs and normal accidents mainly focus on rare but salient events. Qualitative case studies on large-scale accidents and disasters delve into specific cases to explain why and how the events occur. Finally, social psychological studies provide helpful hints on conditions that prevent rare but salient events and how members and organizations will respond to high-velocity situations and unfolding events if those events occur.

The term *problems* indicates that in spite of the abundance of studies on rare but salient events, it is difficult to develop straightforward and generalizable explanations of organizational *causes* of rare but salient events from these studies, resulting in a sense of frustration. With regard to this point, the Royal Society (Christianson et al. 2009; Perin 1995; The Royal Society 1992; Weick, Sutcliffe and Obstfeld 1999) argues that theories on

organizational risk management lack central concepts, demonstrating limitations in their knowledge base. Although the report by the Royal Society was published twenty years ago and researchers have made tremendous efforts since the report, its argument remains appropriate and extends beyond organizational studies. In addition, the limitations argued by the Royal Society seem to be deeply related to the confusion surrounding the causes, phases, preventive measures of rare but salient events, and organizational responses to these events.

Then, what is missing from organizational studies in terms of the organizational decision-making that causes rare but salient events? How does the confusion lead to the missing piece of the puzzle? Below, I review several subfields of organizational studies to clarify the missing piece and confusion.

Organizational Learning: Progress after Negative Events

When rare but salient events become topics for organizational learning, researchers seem to be more interested in the effects of the events on organizational changes (e.g., Lampel, Shamsie and Shapira 2009) than in the effects of organizational decision-making on rare but salient events (e.g., Gavetti, Levinthal and Ocasio 2007). As a result, studies on rare but salient events in this subfield concern organizational changes while the events are occurring (e.g., Beck and Plowman 2009; Christianson et al. 2009; Comfort, Ko and Zagorecki 2004) or after the events end (e.g., Baum and Dahlin 2007; Birkland 2004; Haunschild and Sullivan 2002; Madsen 2009; Morris and Moore 2000). In terms of the three phases of rare but salient events, these studies focus on the phase when the events and high-velocity situations are coevolving or after both of them end. Thus, the studies concern how organizations handle and respond to rare but salient events. In other words, the findings on organizational learning may explain why rare but salient events repeat in spite of or do not

repeat thanks to learning from prior events. However, it remains difficult to explain why the first event occurs. In addition, even with the findings, it is difficult to explain why rare but salient events repeatedly occur, as I describe in this section.

The above characteristics of studies on organizational learning are likely due to the canon of the subfield, i.e., organizational learning occurs as a response to feedback on an organization's performance, especially when its aspiration level is not achieved (Cyert and March 1963; Herriott, Levinthal and March 1985; Huber 1996; Levinthal and March 1993; Levitt and March 1988; March 1991; March and Simon 1958; March, Sproull and Tamuz 1996; Schulz 2002; Simon 1947). Thus, it is difficult to explore organizational learning before rare but salient events generate negative feedback on organizational performance. In this regard, the strengths of this subfield lie in examining conditions under which organizations learn and change from the events (e.g., Baum and Dahlin 2007; Beck and Plowman 2009; Birkland 2004; Christianson et al. 2009; Comfort, Ko and Zagorecki 2004; Haunschild and Sullivan 2002; Kim and Miner 2007; Madsen 2009; Maitlis and Sonenshein 2010; Morris and Moore 2000) and mechanisms with which organizations fail to learn (Baumard and Starbuck 2005; Cohen and Levinthal 1990; Cyert and March 1963; Denrell and March 2001; Feldman and March 1981; Levinthal and March 1993; Levitt and March 1988; March 1991; March and Olsen 1975; March and Olsen 2004; March, Sproull and Tamuz 1996; Schulz 2002; Starbuck 1982; Starbuck 2009).

However, because of the canon and characteristics of this subfield, a blind spot remains concerning why an organization makes a decision that causes rare but salient events. Gavetti, Levinthal, and Ocasio (2007) may agree on this point. The authors argue that among the theoretical foci of the Carnegie school, organizational decision-making and intra-

organizational conflicts have been forgotten since the 1980s and many researchers have been interested in organizational learning and changes for which organizational routines are the unit of analysis.

If the studies in this subfield successfully describe how organizations change after rare but salient events, they may also successfully explain why rare but salient events of similar types repeat in some cases, such as the Space Shuttle Columbia disaster in 2003 following the Challenger disaster in 1986. An explanation for the recurrence is non-learning, or failure of learning, which indicates that organizations cannot always learn and change successfully because of the rarity and uncertainty that accompany rare but salient events (Baumard and Starbuck 2005; Madsen 2009; March and Olsen 1975; March and Olsen 2004; Shrivastava 1983; Starbuck 1982; Starbuck 2009) or because of the limitations of existing capabilities to assimilate the new information needed to change (e.g., Cohen and Levinthal 1990; Cyert and March 1963; Cyert, Dill and March 1958; Lane and Lubatkin 1998; Levinthal and March 1993; Lounamaa and March 1987; Miller 1993; Miller 1994; Schulz 2002; Starbuck and Milliken 1988).

Another explanation is unlearning, or organizational forgetting (Huber 1996; Nystrom and Starbuck 1984), which indicates that organizations cannot retain memories of prior events and consequent learning due to member turnover (e.g., Carley 1996; Chandler 1962; Cohen, March and Olsen 1972; Huber 1996; Nystrom and Starbuck 1984; Starbuck 1983), inadequate recording (Huber 1996), or organizational adaptation to changing environments between the events (e.g., Mahler 2009).

However, these explanations are not sufficient to answer the question of why different members in a different timeframe from the first event respond with inaction to the

potential problems that they observe, at least collectively as an organization. In other words, why do no changes at the organizational level occur in a *fresh* phase of *another* rare but salient event before a *new* high-velocity situation begins? Regardless of whether members have changed and are facing a different environment, some of them observe a potential problem and communicate their concerns to other members (e.g., Columbia Accident Investigation Board 2003; Starbuck and Farjoun 2005).

Regardless of whether organizations learn from the first event, another set of potential problems may or may not trigger actions to prevent the second event under some conditions. The true question about the organizational *causes* of (not *responses* to) rare but salient events is why members' recognition and discussions of potential problems do not surface as changes at the organizational level before a first or repeated rare but salient event occurs.

The above insufficiency occurs because organizational responses during and after the coevolving phase of rare but salient events and high-velocity situations are confused with organizational causes of rare but salient events in the phase before the co-evolution. Another confusion may follow this confusion. The improvement of qualities of organizational responses and on-going learning may be confused with the implementation of possible preventive measures of rare but salient events (e.g., Beck and Plowman 2009; Christianson et al. 2009; Comfort, Ko and Zagorecki 2004; Maitlis and Sonenshein 2010).

At a glance, the improvement of qualities of organizational responses and on-going learning seems to contribute to preventing rare but salient events. However, to prevent rare but salient events, members must know that they are on the verge of facing such an event. Within the canon of the subfield of organizational learning, members do not have this knowledge before they receive negative feedback, i.e., before they are thrown into rare but

salient events. Here again, confusion regarding the phases of rare but salient events is evident. The qualities of organizational responses and on-going learning are issues during the coevolving phase of high-velocity situations and rare but salient events, whereas the possible prevention of rare but salient events is an issue prior to this phase. If a rare but salient event remains preventable, members may be on the verge of negative events, but organizational performance remains intact. In other words, if organizational responses and on-going learning begin, then rare but salient events have already generated negative feedback. Thus, improving the qualities of the responses and on-going learning differs from preventing the events, and confusing these two actions results in arguments that deviate from the fundamental ideas of organizational learning.

If one attempts to explain how to prevent rare but salient events by drawing on theories of organizational learning, this mix-up must first be solved. For example, how could a NASA manager who knew that prior foam strikes had never led to a disaster in the Space Shuttle program pay particular attention to *the* foam strike in *this specific* flight of Columbia for the purpose of organizational learning? On the day when the critical decision was made to land Columbia (Columbia Accident Investigation Board 2003), NASA's organizational performance was intact and members followed ordinary, normal, and routine decision-making processes. No high-velocity situations co-evolved with rare but salient events on this day.

Gavetti, Levinthal, and Ocasio (2007) and Rerup (2006; 2009) provide a helpful suggestion to solve the mix-up. They states that it is necessary to explore organizational decisions on how to handle potential problems that only generate "weak cues" (Rerup 2009) in terms of threats to organizational performance. These problems exist long before, not

during or after, rare but salient events. The focus of the exploration, similar to that of this dissertation, is organizational decision-making before the events, rather than organizational responses to the events.

In short, in this subfield of organizational studies, explanations for organizational decision-making that causes first or repeated rare but salient events are absent. This limitation is mainly a result of the evolution of the subfield, but the confusion surrounding the phases of rare but salient events may also contribute to it. Studies of this subfield cover phases after high-velocity situations and rare but salient events begin to co-evolve, but at the same time, there seem to be tacit expectations that such events can be prevented by improving the qualities of organizational responses during these phases. However, it is necessary to discern organizational responses during the phases from behaviors prior to the phases, such as decisions on how to handle potential problems based on "weak cues" and prevent rare but salient events.

Theories on HROs provide many insights into the utilization of the "weak cues" to prevent rare but salient events. Below, I explore this subfield's ability to explain organizational decisions that cause rare but salient events.

High-Reliability Organizations: Preparation for Events of Any Cause

According to theories of HROs, rare but salient events may be preventable if organizations are equipped with a safety- and reliability-minded culture, flexible routines for high-velocity situations, such as collegial authority and incident command system, situational awareness or mindfulness among members, respect for and empowerment of experts and front-liners regardless of their formal titles, and redundant checking systems of potential problems (Bigley and Roberts 2001; Grabowski and Roberts 1997; LaPorte and Consolini

1991; Roberts 1990; Weick 1987; Weick and Roberts 1993; Weick, Sutcliffe and Obstfeld 1999). Rare but salient events may be preventable with these measures because the organizational culture, members' heightened awareness, and redundant checking systems aid in identifying "weak cues" that may lead to failures or near-failures (e.g., Weick, Sutcliffe and Obstfeld 1999).

The above arguments suggest that whereas studies in the subfield of organizational learning cover the phases after high-velocity situations begin to co-evolve with rare but salient events, studies on HROs cover the phase before and after high-velocity situations emerge. However, they do not include the phase after high-velocity situations begin to co-evolve with rare but salient events. Although these two subfields cover different phases, they contribute concepts to each other to explain rare but salient events. For example, to improve the qualities of organizational responses to and learning from such events, members' situational awareness is essential because it determines how they interpret and structure (Christianson et al. 2009) their understandings of the high-velocity situations that they are encountering. Thus, some of the studies on organizational learning from rare but salient events utilize findings of the studies on HROs (e.g., Christianson et al. 2009; Maitlis and Sonenshein 2010). In addition, because flexible routines may develop through trial and error (e.g., Cyert and March 1963; Feldman and Pentland 2003; LaPorte and Consolini 1991; Schulz 2002), theories on organizational learning and routines development are helpful in explaining how an organization can be an HRO (e.g., Ballesteros 2007; Cook and Yanow 1996; Gaba 2000; Levinthal and Rerup 2006; Sagan 1993; Weick, Sutcliffe and Obstfeld 1999) and prevent rare but salient events.

On the other hand, the differences in the phases that HRO studies cover have led to a different focus on rare but salient events. First, the studies on HROs concern preventive measures of rare but salient events, which may be useful in preventing high-velocity situations from emerging. Second, these studies also concern preparedness that organizations can utilize to control high-velocity situations so that the situations do not develop into rare but salient events. In other words, the interest of the studies lies in organizational responses to high-velocity situations both before and after the situations begin, but the meaning of responses differs from that used in studies on organizational learning. In the studies on organizational learning, the goal of the responses in the coevolving phase of high-velocity situations and rare but salient events for organizations is to learn from the situations and events and improve based on their experiences or observations. In the studies on HROs, the responses before and after high-velocity situations emerge are intended to control the situations and contain rare but salient events as much as possible (e.g., Weick 1988; Weick and Sutcliffe 2006; Weick and Sutcliffe 2007; Weick, Sutcliffe and Obstfeld 1999; Weick, Sutcliffe and Obstfeld 2005).

An interesting point concerning the HRO studies is that the preventive measures and preparedness explained in the studies are not cause-specific. These measures and preparedness are considered universally applicable to HROs. Accordingly, if an organization is an HRO, then rare but salient events may be preventable regardless of the causes of the events. As a result, a researcher who is interested in the causes of rare but salient events can only assume that a lack of the measures and preparedness may lead to rare but salient events. Major case studies in this subfield help to highlight this point.

The case studies on HROs mainly examine special types of organizations that have very specialized missions, such as flight deck crew onboard an aircraft carrier (Weick and Roberts 1993), fire fighters (Bigley and Roberts 2001), forest service (Weick 1993), workers at a nuclear power plant and an offshore drilling installation (Cox, Jones and Collinson 2006), and flight controllers and pilots who are on the verge of encountering a runway incursion (Weick 1990). From these and other case studies, HRO researchers have accumulated insights into how organizations whose missions are prone to disasters can maintain extremely safe records in terms of risk management. Their findings, summarized in the first paragraph of this section on HROs, are interesting; however, it seems to be difficult for organizations that are not special, such as small restaurants, to equip themselves with the same measures because HROs have distinctive characteristics (e.g., Roberts 1990; Weick, Sutcliffe and Obstfeld 1999).

For example, due to the dangerous characteristics of the missions of HROs, safety and reliability are of the utmost priority to the organization (Gaba 2000; LaPorte and Consolini 1991; Roberts 1990; Weick and Roberts 1993; Weick, Sutcliffe and Obstfeld 1999). Their bureaucratic characters enable them to develop detailed safety requirements and standards and to train and order members to comply with these requirements and standards (Bigley and Roberts 2001; LaPorte and Consolini 1991; Roberts 1990; Weick, Sutcliffe and Obstfeld 1999). Their budget has a specialized safety category that is appropriated by legislatures, and in exchange, the legislatures monitor their performance including safety (LaPorte and Consolini 1991; Weick, Sutcliffe and Obstfeld 1999). Due to these characteristics, the situations that theories on HROs describe are unusual, stressful, and rapidly changing; in other words, they are high-velocity situations (LaPorte and Consolini

1991)[2]. These situations demand specially developed routines, such as incident command systems (Bigley and Roberts 2001), that members rely on to contain possible damages to the minimum level.

An HRO is an organization that has these characteristics and equips itself with the measures presented in the first paragraph of this section, including flexible routines that are specially developed for high-velocity situations. HROs are less likely to encounter rare but salient events because they can prevent high-velocity situations. Furthermore, if such situations emerge, HROs can control them so that they do not develop into rare but salient events. However, the characteristics, preventive measures, and preparedness do not provide specific information about the causes of rare but salient events, such as the security holes in airport passenger screening before 9/11. The major interest of the studies on HROs seems to be the management of unexpected situations (Weick and Sutcliffe 2007) with preventive measures and preparedness rather than the identification and removal of specific causes of rare but salient events. As the example of the FAA's successful grounding of airplanes on 9/11 suggests, an HRO can prevent high-velocity situations from worsening regardless of the causes of the situations.

Considering the statistical infrequency of rare but salient events, the HRO studies' approach of disregarding the specific causes of certain rare but salient events and focusing on

[2] A committee member questioned "…what fraction of all organizational types would be covered by this literature? 5%? 1%?". I cannot verify a percentage; however, as the member suggests, the size seems to be quite small. For example, the US has only one Navy whereas there are hundreds of thousands of firms including small businesses in the US (US Census Bureau. N/A. "Statistics about Small Business from the Census Bureau." Washington, DC. http://www. census.gov/econ/smallbus.html, accessed January 8, 2012). Similarly, there are approximately a hundred operating nuclear power "units" (not plants) in the US (United States Nuclear Regulatory Commission. 2000-2011. "List of Power Reactor Units." Washington, DC. http://www.nrc.gov/reactors/operating/list-power-reactor-units.html, accessed on January 8, 2012), and the US Navy owns thirteen aircraft carriers, two of which are under construction (The United States Navy. N/A. "The US Navy Aircraft Carriers List." Washington, DC. http://www/navy.mil/navydata/ships/carriers/cv-list.asp, accessed January 8, 2012). These numbers are far smaller than the number of firms in the US.

measures and preparedness to handle high-velocity situations and contain the events is logical. As Weick, Suttcliffe, and Obstfeld (1999) describe, failures or near-failures are rare to HROs; thus, they may not reoccur and are significant in terms of containment and learning. The statistical infrequency and non-repeatability, however, indicate that the causes of the events may differ from one to another. Members naturally become interested in the causes of the events in the process of containment and learning; however, in developing theories on HROs, it is more efficient to focus on prevention and control than on the specific, sometimes technical, causes of the events. In contrast, in investigating organizational decisions that may lead to rare but salient events, this approach causes the following problem. Without the preventive measures and preparedness, the likelihood that rare but salient events occur may increase, but logically, the lack of these measures and preparedness is not the firsthand cause of the events. In addition, the measures and preparedness do not explain why members collectively make a decision that may eventually lead to rare but salient events.

In other words, confusing an argument on preventive measures and preparedness with that on the causes of rare but salient events may obstruct an investigation of organizational decisions that may lead to such events. The studies on HROs provide valuable insights into how organizations can prevent rare but salient events in the phases before and after high-velocity situations begin to emerge. In contrast to the confusion in the subfield of organizational learning, the HRO studies do not confuse findings and expectations across the phases of rare but salient events. However, explanations for organizational decision-making that may cause these events are absent due to the possible confusion within the phases before high-velocity situations begin to co-evolve with rare but salient events, which is a confusion between the causes of, preventive measures of, and preparedness for those events. Whereas

studies on HROs describe how organizations can prevent high-velocity situations from developing into rare but salient events, those on normal accidents claim that high-velocity situations typically result in rare but salient events regardless of preventive measures and preparedness. The next section discusses studies on normal accidents and rare but salient events.

Normal Accidents: Causes that are out of an Organization's Reach

Concerning rare but salient events, theories on normal accidents offer an opposite prediction from that of theories on HROs. Theories on normal accidents claim that even an HRO cannot prevent rare but salient events because of a two-step mechanism that may cause such events (Perrow 1999; Sagan 1993). First, before high-velocity situations begin, there are complex, tightly coupled systems and centralized organizational designs[3]. According to Perrow (1999), decentralized organizational designs are best suited to control high-velocity situations that involve tightly coupled systems, but these systems demand centralized control on a daily basis. Therefore, if high-velocity situations begin, members must handle problems that involve tightly coupled systems in a centralized manner. Then, in the phase after high-velocity situations begin, unexpected interactions of failures due to the complex, tightly coupled systems override the prepared routines and overwhelm members' awareness while working in the centralized mode of control. As a result, the situations develop into rare but salient events. Due to its interest in how system and organizational characteristics contribute to produce and exacerbate rare but salient events, this subfield on normal accidents covers the phases of such events as follows.

[3] Perrow (1999) explains three other pairs between system complexity and types of coupling as well as the modes of organizational control that are appropriate to each pair. However, in this section, I focus on the pair that Perrow argues inevitably (and thus, most likely among all pairs) leads to rare but salient events to highlight points of the study. For details, see Perrow, Charles. 1999. *Normal Accidents: Living with High-Risk Technologies*. Princeton, NJ: Princeton University Press.

First, it covers the phase prior to high-velocity situations. Second, it covers the phase after the situations begin. Finally, it covers the phase in which the situations and rare but salient events co-evolve. The first two phases are similar to those in the studies on HROs, but the last phase differs.

The above differences and similarities of the two subfields have caused two contradicting phenomena. When researchers are interested in how rare but salient events develop from high-velocity situations and how high-velocity situations begin, the two subfields are considered as opponents (Perrow 1999; Sagan 1993). In contrast, when researchers are interested in controlling high-velocity situations so that organizations can prevent rare but salient events, the two subfields are treated as complements to each other (Gaba 2000; Jarman 2001; Tamuz and Harrison 2006; Weick, Sutcliffe and Obstfeld 1999). It is easy to understand why the former phenomenon occurs. Although these two subfields cover similar phases of rare but salient events, their predictions are in opposition. The latter phenomenon highlights the differences and similarities of the two subfields in more interesting ways. First, in addition to the difference in their predictions, their approaches to rare but salient events differ. Whereas studies on HROs describe preventive measures and preparedness, those on normal accidents describe remote causes of rare but salient events, including complexity and tight coupling in systems and centralization in organizations to control the systems. Second, in addition to the similarity in the phases of rare but salient events covered, the subfields concern the same types of organizations. Both subfields discuss organizations with disaster-prone missions, such as nuclear power plants and the military.

Therefore, if researchers are interested in how organizations can prevent rare but salient events, the subfields do not contradict with each other; rather, they provide

complementary insights. First, if the causes of rare but salient events are the designs of systems and organizations, as studies on normal accidents inform, then researchers can utilize the information by taking designs into account in improving HROs' preventive measures and preparedness. Second, because the subfields consider the same types of organizations and the same phases of rare but salient events, their findings are applicable to each other in a straightforward manner. In short, when researchers are interested in controlling high-velocity situations to prevent rare but salient events, these subfields' differences in predictions are unimportant. Rather, the causes of the events, which studies on normal accidents suggest, and preventive measures, which studies on HROs suggest, seem to become the major concerns. Although the predictions of the two subfields do not overlap, researchers select features from each subfield.

It seems as though the cherry-picking approach mentioned above has led to the missing jigsaw piece in organizational studies in terms of the causes of rare but salient events. With this approach, it is easy to forget the need to examine root causes of the events, which may be embedded in the fundamental characteristics that define organizations. The approach may be practical and efficient for preventing rare but salient events. However, its effectiveness can be questioned because it lacks insights into the root causes of the events and leads to a patchwork of theories and findings whose original predictions are in opposition.

Then, what problems do studies on normal accidents suffer in explaining organizational decisions long before high-velocity situations emerge? Why are the causes that these studies suggest not satisfactory, at least in the eyes of this author? The studies on normal accidents suggest causes of rare but salient events that are far beyond the power and control of an organization. It is a helpful argument that complexities and tight coupling in

systems and centralization in organizations may contribute to rare but salient events after the high-velocity situations begin to develop. However, it is argued that these systems and organizational designs have been chosen because of institutional isomorphism (DiMaggio and Powell 1983) in advanced industrial economies. According to Perrow (1999), as long as "we, the people" allow power elites to disregard the externalities of the complex, tightly coupled systems in exchange for profits and convenience, organizations will encounter rare but salient events regardless of whether they are prepared to handle high-velocity situations. In other words, the views of the studies on normal accidents are in line with those of contingency theory, which states that a certain technology is selected and retained not only because of its superiority to existing technologies but also because of social demands (e.g., Starbuck 1965).

It is difficult to equate the causes of rare but salient events explained from these views with the causes explored from the interest of how an organizational decision emerges from members' collective choices concerning recognized, specific potential problems. In addition, the arguments in the studies on normal accidents leave the following questions about organizational decision-making unanswered: if the causes of rare but salient events lie in the designs of engineering and organizational systems that are chosen because of social demands, why are these events statistically rare? In addition, how do organizations contribute to the infrequency?

Theories on normal accidents seem to suggest that luck is the answer to these questions. According to Perrow (1999), rare but salient events are rare because they demand perfect sets of unexpected, interacting failures that are particular to a specific complex system. The interactions must also be in a specific order. The likelihood that the perfect sets

and order of interactions appear is low; thus, the events are rare (e.g., Perrow 1999:5-9, 45).[4] However, if the public's life and safety depend on luck, although organizations play a role and have responsibilities to control complex systems, what is the significance of organizational decision-making? Studies on HROs seem to have an advantage in answering this question, but neither subfield can directly explain why members collectively choose particular actions against potential problems long before high-velocity situations emerge.

Some qualitative case studies on organizational accidents explain what occurs in an organization when members make a decision long before high-velocity situations develop. In the section below, I discuss these studies by drawing on the example of Vaughan's (1996) study on the accident of the Space Shuttle Challenger.

Qualitative Case Studies: Strict Conditions for Application

Qualitative case studies delve into members' choices long before high-velocity situations begin. With these studies, it is possible to explain why and how members' interactions during ordinary and routine days and consequent organizational decisions lead to rare but salient events. For example, the archival and narrative study on the Space Shuttle Challenger by Vaughan (1996) describes that the organizational cause of the disaster, which reached its climax at the teleconference on the eve of the launch, was a long-term, path-dependent development of decision-making routines of the program. The routines, called "normalization of deviance", caused members of NASA and contractors to expand acceptable ranges of technical risks gradually and incrementally, and the process took longer than five years. There are three conditions of such normalization: production of culture, culture of production, and structural secrecy.

[4] According to the theories on normal accidents, redundancy in complex, tightly coupled systems does not prevent unexpected, interacting failures. On the contrary, it increases complexities in the system, and thus, increases the likelihood of cascading failures.

First, the production of culture refers to the historical development of organizational culture that controls members' decision-making, which clearly began in the Apollo era in the case of NASA. The culture includes members' taken-for-granted belief that technology development is a risky enterprise, in other words, a series of trial and error. Thus, if a trial does not clearly result in an error, even with deviances from a system's specifications, accepting the deviances is a risk that should be taken. To take the risk, requirements in specifications written before the trial, i.e., requirements based on untested, older knowledge, can be waived. The processes for the waiver exist as part of daily routines. To stop the waiver, it is necessary to show data that taking the risk is not worthwhile[5].

Second, the culture of production refers to organizational culture that pressures members toward bureaucratic mindlessness, such as prioritizing launch schedules over safety so that the next fiscal year's budget becomes secure. The culture develops as a response to institutional pressures from outside the organization and trickles down from the top management to front-liners and contractors (Mahler 2009; Vaughan 1997).

The third condition, structural secrecy, is a pathology that is caused by the division of labor and specialization in an organization, in this case, among field centers of NASA. When combined with inter-center rivalry, specialization leads to the containment of potential problems inside a center and a lack of communications across NASA.

When these conditions are met and the normalization of deviance occurs, a shocking phenomenon follows; organizational decision-making processes work to incorporate, rather than expose, potential problems in a system without any rules broken. Technical deviances

[5] Roberto, Bohmer, and Edmondson (2006) call this culture "data-driven culture", and Starbuck and Milliken (1988) name this waiver "fine-tuning" until systems break down. See Roberto, Michael A., Richard M. J. Bohmer, and Amy C. Edmondson. 2006. "Facing Ambiguous Threats." *Harvard Business Review* 84:106-113. and Starbuck, William H., and Frances J. Milliken. 1988. "Challenger: Fine-Tuning the Odds until Something Breaks." *Journal of Management Studies* 25:319-340.

are formally waived, organizational commitments are fulfilled, and empowered center managers make a decision within the established scopes of authority. Without wrongdoing in terms of predefined decision-making procedures, signals of potential problems, especially weak problems, are ignored or, at least, slip out of members' attention.

In terms of the phases of rare but salient events, it is noteworthy that the NASA managers and contractors who were in charge of the ill-destined Solid Rocket Boosters did not face high-velocity situations coevolving with rare but salient events while technical deviances were being normalized. The boosters had caused no major accidents before the Challenger. Shuttle launches completed without disasters, although experienced engineers noticed potential problems in the boosters and repeatedly attempted to communicate their concerns (Presidential Commission on the Space Shuttle Challenger Accident 1986; Vaughan 1996). In spite of the recognized potential problems, no actions were taken during the ordinary and routine days before, and even after, the high-velocity situation began on the eve of the Challenger launch.

In addition, the situation concerned the extremely cold temperature that was expected at the time of the launch, and the potential problems of the boosters were only one of many concerns in the situation. The launch decision was made by managers and contractors who did not know that they would encounter a rare but salient event. Their decision was simply an extension of the ordinary and routine days during which technical deviances on the boosters gradually and incrementally became acceptable.

As the above example shows, the detailed narrative of rare but salient events found in qualitative case studies is helpful in explaining the occurrences among members and in an organization long before high-velocity situations emerge. In addition to the book by Vaughan

(1996), there are many detailed accounts of rare but salient events, such as Casamayou (1993), Cooper and Block (2006), Janis (1972; 1983), Perrow (2007), Snook (2000), Starbuck and Farjoun (2005), Starbuck and Milliken (1988), and Trautman (2000). These accounts also provide direct descriptions, compared to studies in the former three subfields, of members' choices that emerge as organizational decisions and cause rare but salient events.

However, this positive characteristic of qualitative case studies (i.e., detailed and thick in nature) is also their weakness. These detailed and thick studies are specific to the organizations and events in question, and this specificity may cause two problems. First, as occasionally stated, it is difficult to test hypotheses or theories from qualitative case studies compared to those from large-*n* statistical studies (Haunschild and Sullivan 2002; Madsen 2009). Second, when a researcher applies the findings of these studies to other events, s/he is bound to the specific phenomena and conditions that the studies describe; otherwise, the use of the findings may result in misapplications. Below, I focus on this problem by drawing on Vaughan's (1996) study.

The concept of normalization of deviance is quite powerful. It is based on detailed, thick descriptions of why NASA, an HRO, made a poor-quality decision, at least from the post-event perspective. In addition, the term appears to apply to any rare but salient events caused by organizational normalization of deviances. However, to apply the concept and term to other rare but salient events, it is critical to consider what is normalized and how the normalization occurs. In Vaughan's (1996) concept, deviances are technical deviances that are found in technological development but not clear violations of predefined routines. Members can normalize the deviances through formal decision-making processes without committing intentional wrongdoing because the deviances are potential problems found in a

series of trial and error rather than clear violations. The study generates shock and awe because it shows that an organizational accident may occur without members' bypassing or breaking clearly predefined routines rather than because clear violations of routines are accepted, or normalized, over time.

In addition, Vaughan's normalization of deviance has a vital condition; the long-term development of culture that is peculiar to an organization that develops rare, risky technology. Disregarding these critical points while using the concept to explain members' clear violations of predefined routines is equal to describing something clearly wrong with something indeterminately problematic[6] (e.g., Banja 2010; Odom-Forren; Prielipp et al. 2009; Rosness 2009). Causes of rare but salient events that are clear violations by members could refer to the "practical drift" proposed by Snook (2000), which describes how local, minor deviances from clearly predefined routines over time and the interactions of these deviances on the day of a disaster lead to a rare but salient event. These cases could also be investigated as "latent errors", as proposed by Ramanujan and Goodman (2003), which are uncorrected deviances from procedures and policies that do not have direct adverse consequences but with triggering events result in disastrous outcomes.

Thus, although qualitative case studies on rare but salient events provide powerful explanations for organizational causes of such events, the specificity of phenomena and conditions makes it difficult to apply the findings to other cases. Due to this difficulty, it also becomes difficult to explain the nature of causal relationships between organizational decision-making and rare but salient events. Whereas qualitative case studies accumulate rich

[6] With regard to this point, Downer (2010) criticizes that social scientists, when they write about accidents, tend to dismiss engineering judgment based on trial and error easily as errors, deviances, mistakes, and so on, without paying attention to characteristics of engineering profession. See Downer, John. 2010. "On Unforeseeable Future." *Risk & Regulation*:6-7.

but specific descriptions of specific events, they do not provide integrated, straightforward explanations for organizational decision-making and rare but salient events in general.

Social Psychological Studies: Three Independent Approaches to Organizational Issues

Thus far, I have explained why four subfields of organizational studies are not sufficient to identify the relationship between organizational decision-making and rare but salient events and how this insufficiency relates to confusion regarding the phases of such events. Studies on organizational learning focus on the phases of co-evolution of high-velocity situations and rare but salient events and the aftermath of the events; thus, these studies are useful in explaining organizational responses to, not causes of, rare but salient events. Studies on HROs describe the preparation that organizations must perform to avoid and control high-velocity situations. In contrast, studies on normal accidents predict that high-velocity situations inevitably lead to rare but salient events and that organizations face the co-evolution of the two phenomena regardless of their preparedness. Neither the studies on HROs nor those on normal accidents provide straightforward explanations for organizational causes of rare but salient events. In spite of their merits, these three subfields only enable individuals to conjecture the organizational causes of rare but salient events. Finally, qualitative case studies on organizational accidents provide direct explanations of the causes of rare but salient events, considering the period long before high-velocity situations develop. However, the explanations are specific to each case; thus, compiling them does not complete the jigsaw puzzle of the landscape of organizational decision-making and rare but salient events because the various shapes of pieces do not fit to each other.

In this section, I briefly review social psychological studies and their problems in explaining organizational causes of rare but salient events. The studies are briefly reviewed

here because they will appear again in the next chapter, which explains the theoretical model for this dissertation. These studies are helpful in developing the model for two reasons.

First, many of their findings may contribute to model organizational behaviors in the phase long before high-velocity situations emerge. Of note, some of the articles (even though they concern, for example, organizational responses to "threats" or members' "silence" (e.g., Morrison and Milliken 2000; Staw, Sandelands and Dutton 1981)) focus on successful organizational performance rather than rare but salient events. For example, Staw, Sandelands, and Dutton's (1981) proposal of how organizations respond to threats is, in fact, a description of organizational adaptation to changing environments. Similarly, Morrison and Milliken (2000) argue that members' withholding of information on potential problems is a barrier for an organization; however, the barrier refers to problems in developing organizational potential to learn and experiment.

Other studies that attempt to explain members' behaviors that may lead to high-velocity situations and rare but salient events include Tucker and Edmondson (2003) and Weick (1988). Tucker and Edmondson (2003) argue why nurses in hospitals "quick fix" or "patch" potential problems rather than question the systems of their work and contribute to the double-loop learning[7] (Argyris and Schön 1974) of their hospitals. Although the nurses had not yet faced high-velocity situations in the cases in the article, the mishandling of the problems could result in such situations. Weick (1988) argues that it is difficult for members to comprehend the situation while an event is unfolding and thus, they place themselves into

[7] In the article, the authors use the term "first-order learning" and "second-order learning" rather than single-loop and double-loop learning, as used in Lant and Mezias (1996), Fiol and Lyles (1985), and Levitt and March (1988). See Fiol, C. Marlene, and Marjorie A. Lyles. 1985. "Organizational Learning." *Academy of Management Review* 10:803-813, Lant, Theresa K., and Stephen J. Mezias. 1996. "An Organizational Learning Model of Convergence and Reorientation." Pp. 267-301 in *Organizational Learning*, edited by Michael D. Cohen and Lee S. Sproull. Thousand Oaks, CA: Sage Publications, Levitt, Barbara, and James G. March. 1988. "Organizational Learning." *Annual Review of Sociology* 14:319-338.

high-velocity situations under which piecemeal feedback on their actions and their responses to the feedback may lead to rare but salient events.

Second, the method used in this dissertation, an ABS, can solve a problem in the effort to explore organizational causes of rare but salient events by drawing on social psychological studies. I explain the possible contributions and the benefits of the simulation in Chapter 3, but first, I discuss the problem in the effort in the paragraphs that follow.

Social psychological studies spread across levels of analysis, and their units of analysis are not always organizational-level outcomes. There are three types of approaches to the units of analysis: top-down, horizontal, and bottom-up. First, studies with the top-down approach describe how organizations may change members' cognition and behaviors. For example, March and Simon (1958) explain that organizations' unobtrusive control induces members' voluntary compliance through informal and formal projections of expectations, pressures, premises, and standardization. Merton (1940; 1957), Perrow (1986), and Trebilock and Daniels (2006) describe unintended consequences of organizational control, such as bureaucratic personality, pathology, and indecision. Although unintentional, organizational control causes these changes in members' cognition and behaviors. Organizations may also perform cognitive repair of members' minds (Heath, Larrick and Klayman 1998) and nurture an accountability heuristic (Tetlock 1985) that is peculiar to members in the organization. These studies are based on the very basic assumption that organization members must cooperate with each other and coordinate their tasks to realize the organization's goals (Aldrich and Ruef 2006; Barnard 1938; Okhuysen and Bechky 2009; Simon 1947; Thompson 1967).

Second, the horizontal approach indicates that the levels of analysis of independent and dependent variables are the same. In social psychological studies that are staged in an organization, the independent variables are interactions among group members, and the dependent variables are members' choices. For example, Cannon and Edmondson (2001) argue that a team atmosphere that is set by its leader influences members' shared beliefs about whether experimentation and the accompanying failures are acceptable; thus, the atmosphere and leadership types determine members' attitudes toward problem solving. Studies on the groupthink (e.g., Esser 1998; Janis 1972; Janis 1983; McCauley 1989; Whyte 1998) also describe the importance of leadership type, among others, in determining the quality of experts' collective decisions on critical issues of political, diplomatic, and military interest.

The horizontal approach is also applied in studies on the relationship between an individual's attributes, such as beliefs, values, and motivation, and an individual's behaviors. In this category, both the independent and dependent variables are at the level of individuals. For example, Morrison (2006) finds that organization members may intentionally break rules and policies due to their pro-social motivations, such as the welfare of the organization and stakeholders. Daft and Weick (1984) argue that managers' beliefs about degrees to which an environment is welcoming determine their senses of difficulties in understanding it; thus, managers develop different cognitive tendencies to approach and interpret the environment.

Finally, studies with the bottom-up approach attempt to explain how individual cognition is shared among members and how the cognition develops into an organizational cognition. Studies on sensemaking are a good example of this approach (Dunbar and Garud 2009; Weick 1979; 1988; 1993; 1995; Weick and Sutcliffe 2006; Weick, Sutcliffe and

Obstfeld 2005). According to these studies, members develop personal accounts about their environment through the following concurrent processes. First, they note the occurrence of something that deserves their attention. Second, to understand the occurrence, they search for similar events in the past. Third, they talk to each other to develop probable explanations of the occurrence. At this stage, the explanations are piles of different possibilities and simultaneously emerge at the individual and collective levels. Fourth, they test the possible explanations by predicting the next occurrence and determining their actions based on the explanations. Finally, the explanation that passes the test, that is, the one that fits members' emerging view on the environment, is considered appropriate, selected, and retained.

The product of these processes is a shared memory, which is also called organizational cognition. A difficulty in sensemaking, especially in the phases before and after high-velocity situations begin to develop, is that members do not understand the entire situation as the event unfolds and the mindset that is appropriate for an emergency only arises after the clear understanding that a threat is emerging (Weick 1993; Weick and Sutcliffe 2006; Weick, Sutcliffe and Obstfeld 2005). In addition, even after members realize the situation, it is difficult for them to develop a clear picture of the occurrence from their vantage point. Rather, they tend to "think by acting" (Weick 1988), as previously described.

The problem in explaining organizational decisions that emerge from members' collective choices arises from studies that have been developed with the above three independent approaches. Because the interest of this dissertation is organizational-level choices of action and inaction, the studies must be integrated into a multi-level account that connects individual, collective, and organizational levels of analysis (Rousseau 1985). Currently, social psychological accounts seem to be fragmented because their levels of

analysis do not overlap. In addition, a group of researchers rarely employs different units of analysis across studies. To utilize the accounts to explain why members make a collective choice that may lead to rare but salient events, which can also be called *organizational* decisions or *organizational* choices, it is necessary to establish loops and links across the levels of analysis.

For example, the top-down approach lacks upward loops from the individual level. What occurs after members are changed by their organization, especially in terms of organizational-level outcomes? The horizontal approach lacks upward links from the individual and group levels to the organizational level. What organizational-level behaviors arise from individual- and group-level behaviors? Finally, the bottom-up approach lacks group-level accounts, and thus, a link between the group level and organizational level. How do individual members share their cognition as a collective of members before that cognition develops into organizational cognition and choices (e.g., Elsbach, Barr and Hargadon 2005; Salvato and Rerup 2011)?

Without making these loops and links and combining the insights of social psychological studies, the effort to explain organizational causes of rare but salient events may omit some of the studies in the subfield. This will then generate the sense that things do not add up or something remains missing, which I have described in Chapter 1 and this chapter. The multi-level approach is possible with an ABS, as I explain in Chapter 3. Before proceeding to the next chapter, I conclude this chapter with a summary of what organizational studies lack in explaining the causes of rare but salient events.

Summary of the Problems in Organizational Studies

The review in this chapter suggests that none of the five subfields of organizational studies, namely, organizational learning, HROs, normal accidents, qualitative case studies, and social psychological studies sufficiently explain the relationships between organizational decision-making and rare but salient events. Studies on organizational learning explain how organizations respond to problems after high-velocity situations begin to co-evolve with rare but salient events. However, with these studies, it is difficult to explain organizational decisions before members receive negative feedback, that is, before rare but salient events occur. In this regard, studies on HROs have an advantage; however, they focus on organizational preparedness and measures to control high-velocity situations and prevent rare but salient events rather than the causes of the events. Studies on normal accidents explain how rare but salient events occur by considering the phase long before high-velocity situations begin; however, their remote causes are institutional and far beyond organizational. Qualitative case studies on organizational accidents explain organizational causes that develop long before high-velocity situations emerge, but it is difficult to apply their findings to different contexts without presenting misapplications. As a result, it becomes difficult to integrate the findings to explain organizational causes of rare but salient events in a parsimonious manner. Finally, social psychological studies provide rich insights into the organizational causes of rare but salient events, but their units of analysis are not always at the organizational level.

The above subfields of organizational studies have strengths and weaknesses in explaining why and how rare but salient events occur and what is the nature of the causal relationships of organizational decision-making and such events. The common problem

across the subfields is a lack of direct, straightforward explanations about the choices made when members observe potential problems during ordinary and routine days. The explanations must be simple and free from confusion about the phases of rare but salient events, in other words, they must focus on the phase long before high-velocity situations emerge. With this unsolved problem, organizational studies seem to leave a missing piece in a jigsaw puzzle in spite of their richness and power to explain other phenomena.

In the next chapter, I explain how to solve this problem.

CHAPTER 3

WHAT SHOULD BE DONE – A STRATEGY TO FIND THE MISSING PUZZLE PIECE

In the last chapter, I have described why existing organizational studies are missing the puzzle piece of organizational causes of rare but salient events. In this chapter, I explain a strategy to find the missing puzzle piece. First, I explain four points that deserve our attention in finding the piece. Then, I explain why an ABS is useful for the task. Finally, I review the literature on members' interactions and organizational-level outcomes by drawing on social psychological studies, which I briefly mentioned in Chapter 2.

What is Needed to Find the Missing Puzzle Piece

The disadvantages of each subfield of organizational studies, which were explained in Chapter 2, suggest that to explore the relationships between organizational decision-making and rare but salient events, four points must be considered. First, it is necessary to distinguish the phases of rare but salient events. Second, it is necessary to rely on findings from social psychological studies. Third, it is necessary to conduct a multi-level investigation. Fourth, it is necessary to obtain generalizable findings from the investigation. I will explain each point in the paragraphs that follow.

First, in terms of the three phases of rare but salient events, it is necessary to focus on the phase before high-velocity situations emerge, that is, the ordinary and routine days in organizations. During these days, organizations are in the "gray zone" between success and

failure (Rerup 2006) or in the "stage of normalcy (stage I)" and "incubation period (stage II)" of accidents (Turner 1976; Turner and Pidgeon 1997). In these stages, there is no threat to organizational norms and the root causes of future disasters are not conspicuous, although some members report potential problems. During this time, no negative events occur, but members encounter minor near misses, "ambiguous threats" (Roberto, Bohmer and Edmondson 2006), or "latent errors" (Ramanujam and Goodman 2003). Neither the "ambiguous threats" nor the "latent errors" pose immediate dangers to organizational performance, but they may cause rare but salient events if conditions change. Thus, during this period, problems are potential ones in terms of organizational performance and rare but salient events. Here, I elaborate why minor near misses differ from severe near misses to highlight the difference between negative salient events and potential problems.

Although the non-existence of accidents is the best option, near misses are preferable to accidents. When near misses occur, people are expected to learn from the incidents to prevent future disasters (Lampel, Shamsie and Shapira 2009; Macrae 2010; March, Sproull and Tamuz 1996; Morris and Moore 2000; Oktem, Wong and Oktem 2010; Phimister et al. 2003; Tamuz 1987; Weick, Sutcliffe and Obstfeld 1999). For this purpose, systems to report, record, and manage near misses have been developed, and organization members who observe or encounter near misses are required to report the incidents, for example, in the airline, nuclear, chemical, and process industries (e.g., Phimister et al. 2003; Tamuz 1987). However, the requirement has changed the meaning of near misses from incidents that are nearly disasters to any occurrences that catch the reporters' attention (Macrae 2010). The original definition of near misses indicates that incidents are on the verge of threatening life and property but do not result in disasters because of the efforts of organization members

(Kim and Miner 2007; Lampel, Shamsie and Shapira 2009; Macrae 2010; March, Sproull and Tamuz 1996; Weick, Sutcliffe and Obstfeld 1999).

Thus, the original near misses, or severe near misses, are not potential problems. They are the problems that members of HROs handle in high-velocity situations by mobilizing specialized routines. On the contrary, minor near misses do not threat life and property and are not remarkable compared to the severe near misses. These minor occurrences are called near misses simply because they are reported for the requirement. MacRae (2010) labels such occurrences as examples of a "distant-miss" and comments that organizational history and safety-mindedness may determine the threshold of safety breach to report. In other words, minor near misses are potential problems that may or may not lead to rare but salient events. They also occur before organizations and their members face high-velocity situations.

In the phase before high-velocity situations emerge, or during ordinary and routine days, only potential problems arise; thus, members only receive "weak cues" (Rerup 2009) about future possibilities. To utilize terms in the subfield of organizational learning, members have not yet received clearly negative feedback on their aspiration levels during this phase. Many cases of organizational accidents seem to occur because the "weak cues" from potential problems are disregarded during ordinary and routine days.

For example, in Chapter 2, I mentioned the case of the FAA and air carriers, which were not proactive in eliminating the security holes in passenger screening. In hindsight, these organizations missed opportunities to prevent future disasters even though potential problems in the system were recognized. In addition to the problems in passenger screening, the 9/11 Commission concluded that inaction was common across the government

concerning problems that were considered minor (National Commission on Terrorist Attacks upon the United States 2004:101, 350). A problem of this attitude is that no appropriate action may occur until organization members face high-velocity situations and the public is thrown into rare but salient events.

Similar inaction against potential problems are observed in, for example, Hurricane Katrina (Fischhoff 2006; Select Bipartisan Committee to Investigate the Preparation for and Response to Hurricane Katrina 2006), Ford Pinto (Gioia 1992; Schwartz 1990-1991), the explosion at the Texas refinery of British Petroleum (BP) (BP Investigation Team 2005; Hopkins 2010; The BP US Refineries Independent Safety Review Panel 2007; US Chemical Safety and Hazard Investigation Board 2007), the BP oil spill in the Gulf (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011), Love Canal (Beck 1979; Stoss and Fabian 1998), the Challenger accident (Presidential Commission on the Space Shuttle Challenger Accident 1986; Starbuck and Milliken 1988; Vaughan 1996), the Columbia accident (Columbia Accident Investigation Board 2003; Starbuck and Farjoun 2005), and the shoot down of Black Hawks in Iraq (Snook 2000). These cases also suggest that inaction may occur in both the public and private sectors.

By focusing on ordinary and routine days and potential problems, it is possible to explain why and how members make decisions and choices that may lead to rare but salient events that endanger the public rather than how organizations respond to clear and present dangers to their performances and pressures for change. Specifically, why do "gray zone" situations seem to drive members toward inaction against potential problems, and how are "weak cues" disregarded? When are such situations and cues utilized to prevent rare but salient events? Answering these questions is equivalent to explaining the conditions under

which mindful changes of organizational routines occur (Cyert and March 1963; Edmondson, Bohmer and Pisano 2001; Feldman 2000; Feldman 2003; Feldman and Pentland 2003; Pentland and Feldman 2005) and organization members exhibit mindless responses to potential problems (Cohen and Bacdayan 1996; Gersick and Hackman 1990; Staw, Sandelands and Dutton 1981; Weick and Sutcliffe 2006).

The exploration of these conditions is interesting because during the phase before high-velocity situations emerge, there is no "exogenous shock" (Feldman 2003) that may trigger changes in routines (Cohen and Bacdayan 1996; Cyert and March 1963; Feldman 2003; Gavetti, Levinthal and Ocasio 2007; Gersick and Hackman 1990; Levitt and March 1988; Miller 1993; Miller 1994; Nelson and Winter 1982). Therefore, if mindful changes occur, then members' agency is the cause, however, if members provide mindless responses, then members' agency is less likely to be effective (e.g., Becker et al. 2005; Edmondson, Bohmer and Pisano 2001; Feldman 2000; Feldman 2003; Feldman and Pentland 2003; Howard-Granville 2005; Rerup and Feldman 2011).

However, the above exploration does not suggest that organizational routines are the unit of analysis of this dissertation. In some organizational learning studies, organizational routines are the unit of analysis because they are considered to store outcomes of organizational changes (e.g., Becker et al. 2005; Cohen and Bacdayan 1996; Cyert and March 1963; Gavetti, Levinthal and Ocasio 2007; Levitt and March 1988; Nelson and Winter 1982). The interest of this dissertation is, more properly, conditions under which such routines change or do not change without the "exogenous shock" and clearly negative feedback, i.e., conditions under which members choose action or inaction against potential problems and organizational action or inaction emerges from members' choices. To address

this interest, the unit of analysis of this dissertation is organizational-level outcomes of action or inaction against potential problems. Thus, I will search conditions that are important at the organizational level. As the existing organizational studies suggest, actions are likely to lead to changes in routines, whereas inaction is not likely to result in changes. However, the focus of this dissertation is whether action or inaction is chosen rather than whether routines do or do not change[8]. In searching the conditions, it is necessary to rely on inferences from social psychological studies, which is the second point to consider.

Why is it necessary to rely on social psychological studies? In Chapter 2, I explained one of the reasons as follows: these studies provide valuable insights into what occurs in organizations long before high-velocity situations emerge, regardless of whether rare but salient events are the theme of the studies. Another reason is that the study of organizations includes examinations of how members work together; thus, it is essential to examine how members interact in the organization. Organizations are a social mechanism that compel members to cooperate and coordinate for organizational goals (e.g., Barnard 1938; Chandler 1962; Okhuysen and Bechky 2009; Simon 1947; Thompson 1967), although individual members have personal interests and do not always behave as expected (e.g., Aldrich and Ruef 2006; Eisenhardt 1989a; Gouldner 1954; Merton 1940; 1957; Perrow 1986; Selznick 1947). Organizational designs, such as rules, roles, routines, inducements, specialization, and hierarchy, are instruments to compel members to work together. In other words, members make choices and decisions by interacting with each other, and organizational-level choices of action or inaction are the results of those interactions.

Therefore, searching conditions that impact organizational-level choices and decisions is equal to exploring patterns of members' interactions through which members

[8] I am thankful to Professor Howard E. Aldrich, who raised a question that aided in clarifying this point.

develop their collective choices. Social psychological studies describe how interactions among members affect their choices and decisions (e.g., Edmondson 1999; Morrison and Milliken 2000; Weick 1979; Weick 1995; Weick, Sutcliffe and Obstfeld 2005); thus, they are essential in exploring the choices of action or inaction at the organizational level. However, as mentioned in Chapter 2, when drawing upon these studies, it is necessary to connect organizational, collective, and individual levels of analysis in a multilateral manner. This is the third point to consider.

In multi-level studies, factors that impact the unit of analysis interact with each other across the above three levels of analysis in a multi-directional and repeated manner (Rousseau 1985). These factors interact not only in a direction of top-down, horizontal, and bottom-up but also in combinations of these three directions. In addition, the multi-directional interactions are repeated across the levels of analysis. According to Rousseau (1985), one of the best examples of such studies is Staw, Sandelands, and Dutton's (1981) study on rigid organizational responses to adversarial environments.

In the study, the three authors combine the following three factors in a multi-level manner to explain organizational-level outcomes: (1) individual, psychological responses to stressful conditions, such as reduced flexibility, withdrawal, and limited information processing, (2) effects of the individual, psychological responses on group dynamics, which lead to collective decisions of poor quality, such as groupthink (e.g., Janis 1972; Janis 1983) and group polarization (e.g., Isenberg 1986; Sunstein 2007), and (3) effects of (1) and (2) on organizational responses, which include reduced information processing, centralized control, and limited investment of resources to problem solving. These factors interact at and across the levels of analysis and cause organizations to choose familiar, well-tested, routine

responses rather than new and experimental responses, to changing environments. These responses intensify threats from the environments. The intensified threats subsequently reinforce the three effects and their interactions and thus, create a vicious cycle of "threat-rigidity" responses to changes with positive feedback.

The calls for multi-level studies on organizations are not limited to those by Rousseau (1985) and Staw, Sandelands, and Dutton (1981). There have been efforts to link individual cognition to organizational-level outcomes, although some of these efforts do not seem to be successful, such as Brunsson (1985), Edmondson, Bohmer, and Pisano (2001), Feldman (2000; 2003), Howard-Grenville (2005), Kogut and Zander (1992), Rerup (2009), Salvato and Rerup (2011), and Shrivastava (1983). There have also been efforts to avoid mixing individual-level learning with organizational-level learning and to develop theories that are specific to organizational learning (Cangelosi and Dill 1965; Fiol and Lyles 1985; Miner and Mezias 1996; Morris and Moore 2000; Shrivastava 1983; Weick 1996; Weick and Westley 1996), which require the study of the interactions of factors across the levels of analysis. Thus, the idea of a multi-level approach is not new, and these examples suggest that an interesting aspect of organizational studies is the examination of mechanisms with which changes at the individual level develop into those at the organizational level and vice versa.

The model in this dissertation, which examines members' interactions during ordinary and routine days and draws on social psychological studies, must be a multi-level model to explain mechanisms of how organizational-level choices emerge from members' collective choices. It must combine the top-down, horizontal, and bottom-up approaches in social psychological studies that were explained in Chapter 2. The factors that work at and across the organizational, collective, and individual levels include (1) organizational forces

that impact individual members, such as routines, pressures for socialization and adaptation, and power and status structure, all of which control members' interactions, and (2) members' choices, which may eventually change routines and other values at the organizational level. Then, the changed routines and values at the organizational level begin to influence the attributes of individual members, and the cycle continues for a certain period. I specifically explain these factors in the literature review on social psychological studies in this chapter.

Finally, the findings of the above model must be generalizable. With the term "generalizable", I indicate that the findings must be sufficiently weak to test them and apply them to problems of organizational action or inaction in general. In other words, they must be relevant to as many various circumstances as possible, controllable, and replicable. The model must also be as simple as possible. For these reasons, detailed and thick qualitative case studies on organizational accidents are not the option for this dissertation. In addition, the model must be value-neutral, which signifies that it should incorporate conditions for not only inaction but also action at the organizational level by drawing on social psychological studies that propose conditions under which organizations may take action (e.g., Edmondson 1999; Morrison and Milliken 2000).

In summary, for the purpose of this dissertation, it is necessary to analyze patterns of members' interactions during ordinary and routine days, especially the patterns that influence organizational-level choices of action or inaction against potential problems. In addition, the model for the analysis must satisfy three conditions. First, it must be based on social psychological studies on organizations. Second, it must be multi-level so that the findings represent organizational choices and decisions rather than individual members' psychology and cognition. Third, it must be simple and value-neutral so that the findings are

generalizable, controllable, replicable, and applicable. Some of these demands seem to contradict the purpose of this dissertation, which is to explain the nature of relationships between organizational decision-making and rare but salient events. The demand is to explain rare but salient events in a general manner. To overcome this contradiction, an ABS is a useful tool. In the next section, I explain why and how an ABS is useful in finding the missing puzzle piece in organizational studies.

How to Find the Missing Puzzle Piece – Agent-Based Simulation

ABS is a computational social sciences method that allows the observation of how members interact over time and how changes at one level of analysis influence other levels. It also allows one to control the conditions of the interactions and to obtain sufficiently weak and general findings. The characteristics of an ABS that enable these observations and controls include dynamism, emergence, and controllability.

First, dynamism indicates that it is possible to observe changes of states over time (Carley 2002; Davis, Eisenhardt and Bingham 2007; Gilbert 2007; Gilbert and Troitzsch 2005; Johnson 2010; Kelton 1997). In an ABS, agents are endowed with their environment, attributes, positions and connections called "topology", decision rules, and a feedback mechanism to their decisions (Bonabeau 2002; Gilbert 2007; Gilbert and Troitzsch 2005; Johnson 2010; Macal and North 2005; 2006; 2007; Macy and Willer 2002; North and Macal 2007b). Based on these endowments, agents not only interact with each other but also repeat the interactions. The state of agents' interactions may change from one moment to the next, and a researcher can follow these changes numerically and visually. For this dissertation, this characteristic is helpful in following members' interactions that may change their choices of action or inaction against potential problems and observing these changes over time.

In other words, I can observe the collective choices that members make during their ordinary and routine days rather than the choices at a critical moment before a rare but salient event. This observation is similar to, for example, Vaughan's (1996) examination of the several-year history of NASA's decision-making that led to the specific decision on the night before the Challenger launch. However, it differs from, for example, Weick's (1990) examination of the several hours before the clash between two jumbo jets at Tenerife, when flight controllers and cockpit crew could not successfully mobilize their situational awareness and mindfulness.

Second, emergence indicates that an ABS enables a researcher to observe how changes at the agent level cause changes at higher levels, which may or may not be surprising based on agents' attributes and decision rules (Centola, Willer and Macy 2005; Cohen 1981; Dooley 2002; Epstein 2006; Gilbert and Troitzsch 2005; Johnson 2010; North and Macal 2007b). For the purpose of this dissertation, this characteristic is useful in observing changes in each member's choice, changes in their collective choice, and differences at the organizational level between choices of action and inaction. In addition, feedback to agents serves as a learning mechanism and triggers changes in their behaviors when conditions are met. Thus, it is possible to design an ABS in which changes at higher levels may also affect individual agents (Gilbert 2007; Gilbert and Troitzsch 2005; Johnson 2010; Law 2006a; Macal and North 2005; 2006; 2007; North and Macal 2007b). In other words, an ABS enables a researcher to conduct a multi-level study in which agents interact and decide at one level, effects of the interactions and decisions change outcomes at higher levels, and changes at the higher levels influence agents' interactions and decisions. This characteristic of an ABS is advantageous for this dissertation because its strategy includes

linking top-down, horizontal, and bottom-up approaches in social psychological studies and determining the patterns of members' interactions that impact organizational-level decisions.

Third, controllability indicates that because an ABS is a computer program, a researcher can control conditions that may generate the observed states (Adner et al. 2009; Davis, Eisenhardt and Bingham 2007). The conditions and their outcomes are replicable and testable, and findings from an ABS can explain rare but salient events in general if agents' endowments are general, i.e., not as specific as, for example, the production of culture that occurs in an organization such as NASA that develops risky technology (Vaughan 1996). With this controllability, if an ABS is designed with a balance between the purpose of the study, construct validity, and internal validity, it can be used for a wide range of purposes including normative studies, hypotheses testing, and theory formation and exploration (Burton and Obel 1995; Davis, Eisenhardt and Bingham 2007; Thomsen et al. 1999). Davis, Eisenhardt, and Bingham (2007) argue that an ABS can advance understandings of existing studies when those understandings seem to be firm but further collection and testing of empirical data are difficult.

According to these arguments, an ABS seems to be promising for this dissertation for three reasons. First, this dissertation aims to make propositions on why rare but salient events occur from the viewpoint of organizational studies, and an ABS is useful for theory exploration. Second, the model of this dissertation relies on inferences from social psychological studies to make the propositions. The findings of such studies are firm; however, due to the rarity and uncertainty of rare but salient events, further data collection and testing based on the findings are difficult, especially under controlled conditions. An ABS helps to solve this problem. Third, the controllability of an ABS allows experiments

with conditions that may lead to rare but salient events, which is not acceptable in the real world. In addition, in real organizations, when or whether such events will occur are unknown, which makes fieldwork expensive and impractical.[9]

The controllability of an ABS may also become its weakness; its outcomes do not provide information about relations between individual members' traits or personality and their choices. As mentioned, an ABS is a computer program and the simulation is programmed. Unlike experiments and observations of real human subjects, there are no surprises from unexpected psychological orientations (e.g., Gouldner 1954; the Hawthorne effect in Scott 1981). Even if a researcher incorporates different psychological orientations into agents' attributes, variations in outcomes due to the various orientations are within the range of algorithmic branching, i.e., differences by programming. This weakness signifies that the outcomes of an ABS are meaningful only in terms of relations between limited attributes of agents and emergent outcomes from interactions among those agents. Thus, the focus in this dissertation is the emergent outcomes from an ABS rather than the agents' attributes.

However, this weakness is also strength of the ABS. First, it is not necessary to consider noise that agents' unexpected attributes may generate in the data. In the case of human subjects, noise may result from, for example, the demonstration effect and social desirability effect when a topic concerns sensitive and ethical issues, such as decisions that lead to rare but salient events. Second, the strategy of this dissertation is to find the missing puzzle piece of rare but salient events by investigating the conditions of organizational action and inaction, and these conditions depend on how agents interact rather than their

[9] I am thankful to Professor Howard E. Aldrich, who identified the third reason that an ABS is practical for the study of rare but salient events.

psychological orientations. As stated in Chapter 1, this dissertation concerns organizations that consist of carefully selected, dedicated, and diligent members, not potential criminals or those who tend to commit deviant behaviors. Thus, the limited attributes of agents and controlled conditions in the ABS are an advantage, not a problem, in this dissertation.

Then, what endowments must be included in the ABS of this dissertation? To answer this question, I review social psychological studies to make inferences about members' interactions and organizational-level outcomes in the next section. In the review, I categorize the studies into three groups. The first group describes the organization, which is the environment of agents in the ABS. This group of studies also informs how top-down, horizontal, and bottom-up approaches work together. The second and third groups focus on how members interact; thus, inferences from these two groups of studies provide accounts of topology, decision rules, and the feedback mechanism of agents. In other words, the inferences are helpful in clarifying how the three approaches work together in the ABS, such as how members interact at the collective level. Because these two groups of studies make different predictions about organizational-level action and inaction, I utilize both to explain the same endowments to achieve a value-neutral investigation. The predictions seem to be equivalently credible, and it is not possible to determine which predictions are correct, or at least more correct, before running the ABS. Finally, inferences from all three groups of studies are helpful in determining the agent attributes to include in the ABS.

Theories on Members' Interactions and Organizational-Level Outcomes

The first group of studies suggests that organizations consist of members who are carefully selected, successfully socialized, and continuously adapting, in other words, those who have similar orientations. Organizations select applicants not only based on their

competencies but also based on their psychological fit (Aldrich and Ruef 2006; Whyte 1956). For the selection, various methods of psychological evaluations have been developed (e.g., Braun, Wiegand and Aschenbrenner 1991; Côté and Miners 2006; Milgram 1991; Rath Jr. and McCarroll 1991; Whyte 1956). In some cases, evaluations have been specifically developed for high-risk jobs, such as fighter pilots and astronauts (Braun, Wiegand and Aschenbrenner 1991; Picano, Williams and Roland 2006). As a result, the selectees tend to share attributes that align with the existing organizational culture. Then, once they join the organization, they undergo socialization and adaptation processes and their learning continues through their tenure (Ashforth and Anand 2003; Ashforth and Saks 1996; Chao et al. 1994; Chatman 1991; Davis-Blake and Pfeffer 1989; Lutfey and Mortimer 2003; Ostroff and Kozlowski 1992). Through the socialization and adaptation processes, members including newcomers acquire explicit and tacit knowledge about organizations, such as formal and informal work relationships and power structure (Chao et al. 1994), and become committed to organizational goals (Allen and Meyer 1990).

By selecting members who have a higher potential to fit and socializing these members, organizations build the foundation to compel members to cooperate, coordinate, and collectively perform well for organizational goals (e.g., Barnard 1938; Okhuysen and Bechky 2009). However, it is also argued that through socialization, organizations may reduce diversity among members and hamper their will for experimentation (Herriott, Levinthal and March 1985; Levinthal and March 1993; March 1991). Others also argue that organizations "program" members to generate certain ranges of actions (Allison 1971; Roberto, Bohmer and Edmondson 2006; Starbuck 1982; 1983). Similar arguments claim that organizations modify individual members' behaviors (Barnard 1938; Simon 1947; Thompson

1967), repair their mental maps (Heath, Larrick and Klayman 1998), and quicken their judgment with accountability heuristic (Tetlock 1985). These social psychological effects are top-down from the organizational level to individual members and lay the groundwork for first, interactions among members who are comparatively homogenous and responsive to homogenizing pressures and second, members' shared cognition or common understanding concerning what is desirable in the organizations. Because the first point has been discussed above, I explain the second point below.

The common understanding may consist of many components. It may include knowledge to perform tasks in a smooth and coordinated manner, knowledge about other members, and desirable attitudes and beliefs (Cannon-Bowers and Salas 2001; Kogut and Zander 1992), called cognitive or organizational schemata (Aldrich and Ruef 2006; DiMaggio 1997; Elsbach, Barr and Hargadon 2005; Rerup and Feldman 2011). It may also include shared meanings, beliefs, norms, and routines with which members can successfully explain unfamiliar events and solve problems (Battenhausen and Murninghan 1985; Becker 2004; Becker et al. 2005; Cohen 1996; Cohen and Bacdayan 1996; Feldman 1984; Gersick and Hackman 1990; Levinthal 1996; Verhagen 2001; Weick 1995).

The common understanding among members develops from their interactions as the horizontal approach in social psychological studies describes, and it returns bottom-up effects to the collective and organizational levels. For example, members' interactions, such as discussing actions and successful options, are essential for sensemaking and shared understandings among members (Hatch 1999; Weick 1979; Weick, Sutcliffe and Obstfeld 2005). Through these interactions, the accounts of an event are shared and checked against the situation. Then, highly plausible explanations are shared and retained and eventually

become organizational memory (Weick 1988; Weick 1995). This process is the same at the group level. When team members meet unexpected situations in their daily tasks, they update their common understanding by interacting, specifically, communicating to improvise concerning next steps (Bechky and Okhuysen 2011).

Cognitive schemata and routines also evolve through members' interactions (e.g., Nelson and Winter 1982; Okhuysen and Bechky 2009). Regular cooperation and coordination may lead to knowledge transfer and sharing among members (Kogut and Zander 1992). When routines develop and change, members negotiate which of their similar experiences is useful in the current situation (Battenhausen and Murninghan 1985). In addition, socialization and adaptation are interpersonal processes (Ostroff and Kozlowski 1992). For example, when a member faces "surprises" (Louis 1980) in the course of socialization, interactions with other members help the member to adjust his/her individual understanding to the more common understanding in the organization (Louis 1980; Louis, Posner and Powell 1983; Morrison 1993; Sluss et al. 2012). As a result, socialization becomes more effective and understandings among members become less varied.

The horizontal interactions and bottom-up effects above do not end when the effects reach the collective and organizational levels; rather, they return to the individual level. This echo of the effects across the levels of analysis may continue indefinitely. For example, the knowledge, beliefs, meanings, norms, and routines become structured and constitute organizational culture (Cook and Yanow 1996; Fiol and Lyles 1985; Schein 1990). Then, the culture begins influencing members' decisions and behaviors (Aldrich and Ruef 2006; Allison 1971; Becker 2004; Cohen and Bacdayan 1996; DiMaggio 1997; Edmondson and Moingeon 1998; Miller 1993; Okhuysen and Bechky 2009; Staw, Sandelands and Dutton

1981; Vaughan 1996; Verhagen 2001). Understandings, cognitive schemata, and routines shared among members continue to change in the short term and long term (Becker 2004; Gersick and Hackman 1990; Nelson and Winter 1982; Rerup and Feldman 2011; Weick 1988). This suggests that members' interactions change common understandings at the collective and organizational levels and that these understandings continue to influence individual members' choices and decisions.

In addition, interactions among members serve as a tool of unobtrusive control that generates informal pressures, encourages the internalization of expectations, tacitly sets standards of behavior, and induces voluntary compliance with what is desirable in organizations (March and Simon 1958). Compliance reinforces existing understandings about what is desirable in organizations whereas noncompliance, which is an unexpected outcome, may change the understandings. Thus, members' interactions and the evolution of organizational characteristics are interactive, iterative, and long-term processes across the individual, collective, and organizational levels.

These member characteristics, their interactions, and organizations must be translated into the environment and agents' attributes in the ABS. First, agents constitute a comparatively homogenous population, although a certain variance in the population is expected. Second, as a collective, agents have a common understanding of what is desirable in an organization, and an agent has personal opinion about what is desirable. Finally, agents repeatedly interact with each other, and the interactions may influence an agent's opinion and the agents' common understanding, which may eventually emerge as changes in understanding at the organizational level.

Both organizational-level action and inaction may result from common understandings and interactions among comparatively homogenous members. This likely explains why the other two groups of social psychological studies provide opposite views on relationships between members' interactions and the organizational-level outcomes. The second and third groups provide insights into members' interactions and the results of the interactions; thus, inferences from these groups of studies are helpful in designing agents' attributes, topology, decision rules, and feedback mechanism to their decisions. As I explain in the following paragraphs, the second group of the studies claims that organizational inaction is chosen due to members' interactions, whereas the third group proposes that organizational action is chosen.

The second group of social psychological studies suggests that members' interactions lead to inaction at the organizational level and rare but salient events are inevitable. For example, according to theories on the groupthink (e.g., Esser 1998; Janis 1972; 1983; McCauley 1989), when highly educated, professional, diligent, and dedicated members interact and do not perceive an imminent threat, they may choose to disregard potential danger, as in the case of Pearl Harbor[10]. Gioia's script study on the case of Ford Pinto (Gioia 1992) suggests that members discussed potential problems but did not believe that what they were doing were problematic; thus, they did not take remedial action. In the case of the space shuttle accidents, such as the Challenger and Columbia, members who once raised their voices about potential problems *chose* to remain quiet after they discussed the problems with managers at higher tiers (e.g., Columbia Accident Investigation Board 2003; Dunbar and

[10] McCauley (1989) argues that Pearl Harbor is not a case of the groupthink because it lacks promotional leadership and insulation from outside opinions. However, he agrees that the Navy decision makers were a cohesive, homogenous group that lacked a sense of threat from the other side of the Pacific. For details, see McCauley, Clark. 1989. "The Nature of Social Influence in Groupthink: Compliance and Internalization." *Journal of Personality and Social Psychology* 57:250-260.

Garud 2009; Presidential Commission on the Space Shuttle Challenger Accident 1986; Starbuck and Farjoun 2005; Vaughan 1996).

In addition to the above findings on horizontal interactions at the collective level, this group also indicates a loop between top-down effects from the organizational to individual levels and bottom-up effects to the organizational level. The two effects work together in that the common understandings among members cause them to choose inaction because once these understandings develop, they begin to restrict members' choices and decisions, as previously explained. For example, cognitive schemata are more likely to induce automatic, taken-for-granted responses than to encourage changes among members (Aldrich and Ruef 2006; DiMaggio 1997). Organizational and cognitive schemata are highly general and habitual; thus, it is costly to change them, even if the change is necessary (Weick and Sutcliffe 2006). Therefore, these schemata are likely resistant to changes. Routines also have a status quo bias for the following reasons.

First, without a clear failure, i.e., clearly negative feedback, changes typically do not occur (Cohen and Bacdayan 1996; Cyert and March 1963; Gavetti, Levinthal and Ocasio 2007; Levitt and March 1988; Miller 1993; Miller 1994; Nelson and Winter 1982). Second, routines encourage habitual, mindless responses regardless of situations because these automatic but quick responses are positive functions of routines if such a simple-minded application is acceptable (Cohen and Bacdayan 1996; Gersick and Hackman 1990; Staw, Sandelands and Dutton 1981). Third, it is difficult to change routines because they are tacit knowledge (Polanyi 1966). In some cases, many members are involved in developing the routines, and the development is an on-going process. Due to these characteristics, routines are difficult to "observe, analyze, and describe" (Cohen and Bacdayan 1996:403). As a result,

routines do not change, organizational inaction is chosen, and rare but salient events are inevitable.

However, some researchers who study common understanding, especially routines, have different opinions on these negative top-down effects and subsequent bottom-up effects (e.g., Feldman 2000; 2003; Feldman and Pentland 2003). For example, Howard-Granville (2005) argues that whether routines become persistent and habitual or flexible and responding depends on members' intentions, orientations, and contexts, such as organizational culture, patterns of coordination, and usage of technology. The different view on routines is reviewed in detail in the discussions of the third group of studies.

The second group of social psychological studies provides another interesting explanation about horizontal interactions at the collective level and their top-down effects on individual choices and decisions. Theories on the bystander effect and social impact theory suggest that individuals may select inaction, even when observing an individual who needs assistance, due to mutual attention to their attributes and behaviors and the number of other bystanders (Latané 1981; Latané and Nida 1981; Petty et al. 1977).

According to the theories on the bystander effect, there are several steps in rescuing action, but social psychological effects intervene in these steps. First, the individual must perceive that an unusual event is occurring and interpret it as an event that deserves his/her action. However, when others are also watching the event, the individual may consider the possibility that s/he is misinterpreting the situation and on the verge of overreacting. If others do not agree with his/her interpretation, his/her rescuing act will embarrass others and himself/herself. All of the bystanders face this "potential embarrassment", and as a result, no one takes a decisive step to initiate action. Second, even when the individual's interpretation

is correct, s/he must feel that it is his/her responsibility to handle the situation. However, when there are many other bystanders, it is difficult to feel responsible and risk one's life. In other words, the "diffusion of responsibility" intervenes in the steps for the individual to take action.

Third, the individual must possess sufficient skill or resourcefulness to rescue the person in need of aid. Otherwise, other bystanders may accuse him/her of making the situation worse. Thus, other bystanders cause the individual to worry about potential perceived failure, which inhibits him/her from taking action. This intervening effect is called "audience inhibition". All of the bystanders may feel the mentioned effects, and as a result, no one takes action to help the person in need of aid.

Social impact theory elaborates factors that impact the above intervening effects and the individual's decision. According to the theory, there are three factors, social strength, distance in time and space, and the number of bystanders. When a source of influence, i.e., one of the bystanders, is socially stronger than the individual in terms of power, status, age, etc., and when the source is closer to the individual in time and space, the source will be more influential on the individual's decision. If the number of bystanders increases, the individual will be more likely to feel the impact of their strength and distance as a whole. However, the impact will only marginally increase due to the "psychosocial law" even if the number of bystanders increases. The three factors and the psychosocial law are explained in detail later because they are critical to defining two of the agents' decision rules, the initiating rule and change rule.

Although the theories are not specifically about organization members, they have important implications for the current ABS, especially concerning members' interactions and

organizational-level choices of action or inaction. First, interactions among members may constrict their individual choices and cause them to choose inaction against potential problems as a collective. It is necessary to run the ABS to confirm this inference. Second, interaction includes paying attention to other members' thoughts and incorporating their ideas into one's decision. In the ABS, changes in an agent's opinions must occur by taking into account the opinions of other agents with whom the agent interacts. Third, in the process of interactions, the following factors, among others, also influence members' decisions: one's expertise, power and status structure, order of interactions, and the number of other members with whom a member interacts. These factors first become agents' attributes, such as expertise and power and status, and then become their decision rules, such as the initiating rule, the search rule, and the change rule, as simulation models develop from the minimalist to full-scale models.

The question remains whether these theories explain members' interactions in the phase of rare but salient events before or after high-velocity situations emerge. The theories seem to concern the phase before high-velocity situations emerge, as bystanders have time to think about and choose their actions. The person in need of aid is in a high-velocity situation, as defined in Chapter 2. S/he may exhibit the fight-or-flight response and have little time to think, and the margin of error may be small for his/her survival. In contrast, bystanders are not in a situation of the same velocity. They can observe the other bystanders' behaviors and appearance, consider their personal expertise and responsibilities, and literally choose to *walk* away rather than *run* away. The findings in the bystander effect and social impact theory focus on the bystanders, not the victims; thus, they concern the phase of rare but salient

events before high-velocity situations emerge. Therefore, the inferences from the theories in the previous paragraphs are useful for the ABS of this dissertation.

Thus far, the review has focused on organizational inaction. However, the purpose of this dissertation is to determine the conditions, or patterns of members' interactions, under which organizational-level outcomes change, i.e., choices of organizational action or inaction emerge. Thus, the ABS of this dissertation must incorporate findings of the third group of social psychological studies, which makes the opposite prediction to that of the second group.

The third group of the studies assumes that members' interactions are essential for detecting and solving potential problems and calls for managerial efforts to create an organizational culture and atmosphere that encourages members to discuss the problems. An example of this line of argument is studies on organizational silence (Milliken, Morrison and Hewlin 2003; Morrison and Milliken 2000). Organizational silence occurs when members are aware of problems but do not report them. There are three reasons why they do not report these problems. First, the management sends signals, whether explicit or implicit, that reporting problems is not welcomed. For example, in an organization, there may be a gap between what is verbally explained, such as "safety first", and how members who report violations of safety requirements are sanctioned, i.e., negatively (e.g., Ashforth and Anand 2003; Lee et al. 2004; Morrison and Milliken 2000).

Second, mid-tier managers convey the will of the management to lower-tier members in daily interactions. The managers may also send explicit and implicit signals in the interactions. Third, because of these behaviors of the management and mid-tier managers, lower-tier members understand that speaking up on problems is unacceptable in their organization and do not take a chance. To prevent organizational silence, theorists emphasize

the managerial responsibility to recognize the negative effects of members' silence on organizational performance and to create an environment in which members can safely speak up.

The studies on team psychological safety (TPS) (Cannon and Edmondson 2001; Carroll and Edmondson 2002; Edmondson 1999; Hofmann and Jones 2005) concern members' speaking up in subunits in organizations. According to the studies, TPS is an essential condition to prevent subunit-level problems from propagating through an organization. TPS theorists argue that when a team leader successfully creates an atmosphere in which members safely report the errors that they commit, the unit can efficiently and effectively catch and solve problems (Edmondson 2002; Tucker and Edmondson 2002). The safe atmosphere can also be called a trust relationship between (1) a leader and members, in which members can believe that they will not be negatively sanctioned by honestly reporting their errors, and (2) members, in which they can believe that those who report errors are not ridiculed by coworkers. Although the studies on TPS are empirical compared to those on organizational silence, both share the idea that members' speaking up is important for subunits' and organizations' performance and that the roles of leaders and managers are crucial for encouraging members to report problems.

The above two studies imply that if interactions occur in an atmosphere that is open to speaking up, then individual members may discuss potential problems; thus, interactions at the collective level influence individual decisions. This condition must be translated into an agents' decision rule about initiating interactions with other agents, that is, the initiating rule.

This group of studies also implies that bottom-up effects from the individual and collective levels to the organizational level may contribute to preventing rare but salient

events. For example, TPS is also considered to aid learning at the collective level because the leadership and team atmosphere that is open to the reporting and discussion of errors may lead to changes in routines and better outcomes (Edmondson, Bohmer and Pisano 2001). If the betterment extends from the collective to the organizational level, the extension is a bottom-up effect and the collective learning and consequent changes in the common understanding may cause members to choose action against potential problems.

This view of flexible routines is opposite to the previously discussed view of persistent routines. In the flexible routines view, routines are considered sources of changes rather than organizational inertia because members can utilize existing routines to change current business processes, for example, by combining them, disregarding them, and even undermining them (Becker et al. 2005; Feldman and Pentland 2003; Nelson and Winter 1982). In this case, members' agency, or mindfulness, is more powerful than the inertia that routines render and members evaluate and choose routines in terms of the routines' effectiveness and efficiency in a certain context (Becker et al. 2005; Feldman 2000; 2003; Feldman and Pentland 2003). Thus, a bottom-up effect from the individual level may change the common understanding at the organizational level, which may also prevent rare but salient events.

Although studies on HROs are not always categorized as social psychological studies, such a categorization is possible (e.g., Cox, Jones and Collinson 2006; Grabowski and Roberts 1997) because these studies assume that member reporting and managerial encouragement are preconditions to preventing rare but salient events.

This group of studies seems to be a natural response to the following fundamental characteristics of formal organizations: division of labor, specialization, and hierarchy.

Because members are divided into subunits and given specialized responsibilities, managers cannot successfully manage their organization unless members report potential problems. Then, the information must be passed along a hierarchical ladder (Barnard 1938; Cyert and March 1963; March and Simon 1958; Simon 1947). If a problem does not warrant managerial attention, the appropriate subunit must catch and solve it. In addition, this group of studies seems to imply that members' interactions may not contribute to preventing rare but salient events without conditions that secure positive outcomes of the interactions, that is, action at the organizational level against potential problems (e.g., Zhao and Olivera 2006). However, it is necessary to run the ABS to examine the extent to which these conditions are essential for organizational-level action, especially because the studies on routines predict that members' agency and mindfulness generates a bottom-up effect that may lead to organizational action.

Among the three fundamental characteristics of an organization, that is, division of labor, specialization, and hierarchy, the first two characteristics are translated into an agent's attribute of expertise, as I explain in the next section. Here, it is necessary to discuss the third characteristic, hierarchy.

Hierarchy is a rank order in an organization based on members' power and status, and the power and status has formal and informal aspects (e.g., Magee and Galinsky 2008). The formal power and status consists of members' formal titles, and the informal aspect consists of members' impressions of a member's competencies, usefulness, and helpfulness (Baldwin 1989; Beekun and Glick 2001; Blau 1955; Dahl 1963; Homans 1958; Magee and Galinsky 2008; Pedone and Conte 2001). The impressions are not always correct, but an informal power and status structure develops from these impressions (Berger and Fisek 1970; Bolino

1999; Cook, Molm and Yamagishi 1993; Magee and Galinsky 2008; Wagner and Berger 1993; Willer and Markovsky 1993). Both the formal and informal aspects of a member's power and status determine his/her influence in an organization, that is, how seriously other members listen to, consider, and follow his/her opinion (e.g., Magee and Galinsky 2008; Merton 1968). Thus, differentiation in members' power and status affects changes in organizational routines, especially when the changes occur in a bottom-up manner. Members with greater influence can force others to face and accept the cost of changing existing business processes (Feldman 1984; Feldman and Pentland 2003; Howard-Granville 2005). Such members can also insist that existing routines remain intact, and others will seriously consider the opinion.

These properties of hierarchy in an organization, or members' power and status, provide three implications about agents' endowments in the ABS of this dissertation. First, agents must possess an attribute of power and status, and this attribute must consist of formal and informal elements. Second, agents' decision rules must reflect differences in their power and status. Third, agents' power and status may change because of their individual choices through interactions, and this change serves as a feedback mechanism. For example, on the one hand, if an agent chooses an opinion that differs from that of most agents, the agent's power and status, especially the informal elements, will decrease. On the other hand, the power and status of an agent that consistently makes choices that are similar to the organizational-level choices will continuously increase. This is similar to a real-life organization in which members may assume that an individual whose judgment is always correct is competent and reliable. The change in an agent's power and status also leads to changes in the entire structure of agents' power and status; thus, the environment of

interactions also changes. In the interactions that follow, agents are in the new power and status structure.

The second and third groups of studies lie at each end of an array of conditions for organizational action and inaction. One end represents conditions for the organizational inaction that seems to be a natural outcome of members' interactions. The other end represents conditions for the organizational action that seems to become possible by conditioning members' interaction. It is an array because either-or hypotheses seem to be inappropriate. With the second group of studies, it is difficult to explain why rare but salient events are high-consequence but low-probability events. With the third group of studies, it is difficult to understand why such events occasionally occur. It seems to be more appropriate to consider sets of conditions spread between the two extremes. For the purpose of this dissertation, it is necessary to examine the conditions under which action turns into inaction, or vice versa, with an ABS. If no such transition occurs and only organizational action or inaction is observed regardless of the conditions, either the second or third group of studies will be more robust to explain whether choices of organizational action or inaction result from ordinary, routine interactions among members and how and why the outcome occurs.

From Inferences to the ABM: Summary of Agents' Endowments

In the last section, I have explained implications of social psychological studies on members' interactions and organizational-level choices of action and inaction. I have also briefly mentioned the operationalization of inferences from these studies into the agents' endowments in the ABM of this dissertation. This section is the summary of these endowments.

Environment. In the ABM in this dissertation, agents are members and their environment is their organization. The environment consists of a space that is defined by vertical and horizontal grids. For the current ABM, I set the space of 50 grids by 50 grids. Agents randomly spread inside the space. In each round of interactions, that is, at each tick of the simulation, an agent interacts with the total number of agents minus one counterpart at the maximum. The agents have topology, decision rules, and a feedback mechanism as well as the attributes of an opinion, match of expertise, and power and status. These attributes are each agent's characteristics; however, they have different implications at the organizational level, as explained below.

Opinion. An agent's opinion is its idea about what is desirable in the organization. "What is desirable" at the agent level indicates the agent's idea concerning potential problems in the organization and action against the problems. In other words, the agent's opinion reflects a member's sensitivity to the "weak cues" and his/her willingness to take action against potential problems. At the organizational level, agents' opinions as a whole are comparable to members' norms, beliefs, routines, shared meanings, or cognitive/organizational schemata that embody the common understanding concerning "what is desirable" in the organization. Shapes of the distribution of these opinions show how an organization has successfully socialized its members because, as the first group of the social psychological studies suggests, processes of application and selection, socialization, and adaptation result in a comparatively homogenous population of members.

Match of Expertise. This agent attribute refers to a match between the agent's expertise, such as skills and knowledge, and the field of potential problems observed. As the second group of the social psychological studies (especially social impact theory) suggests,

the match between an agent's expertise and the field of potential problems determines whether an individual is willing to take action against the problems. Thus, this attribute is also essential in terms of an agent's decision to begin interactions. In addition, the informal aspect of an individual's power and status includes his/her competency. Therefore, an agent's match of expertise may influence how seriously other agents consider the agent's opinion. In other words, the attribute of match of expertise may influence an agent's decision concerning whose opinions to take into account while interacting with other agents.

The above descriptions concern this attribute's meaning at the agent or individual members' level. At the organizational level, the distributions of values of this attribute show the degree of specialization in an organization. According to the third group of social psychological studies, specialization may be a cause of organizational inaction. The group of studies demands managerial and leaders' attention to organizational silence, TPS, and expert opinions because it becomes more difficult to catch potential problems as members become more specialized. The ABS in this dissertation will provide insight into whether degrees of specialization impact organizational inaction.

Power and Status. There are two types of power and status, those that accompany the agent's formal rank and those based on other agents' appreciation of the agent's competency and helpfulness. At the organizational level, the distribution of power and status among agents shows an organization's formal and informal hierarchy.

Both the second and third groups of the social psychological studies suggest that members' power and status is important for their interactions and decisions. The two groups of studies suggest that power and status differences among members may influence their willingness to pay attention to others' opinions and to take action. The studies also imply that

power and status relations among members may change in conformity with the fit of members' decisions to the organization's common understanding. Thus, the attribute of power and status is essential for two of the agents' decision rules. First, it is essential for the search rule, which defines the agents with which they interact. Second, it is essential for the change rule, which determines which agents' opinions they take into account. The attribute is also important for the feedback mechanism to agents. Details of these decision rules and mechanism are explained in the paragraphs on "Decision Rules" and "A Feedback Mechanism".

Topology. Topology in an ABM defines relations between agents. Major types of the topology are network and geography, which define the strength of agents' connections, locations of agents, or distances between agents, for example. The topology also defines the agents with which an agent may interact and exchange resources. In the models of this dissertation, agents randomly spread in the grid space and they interact and exchange their opinions depending on their decision rules. In other words, the agents' locations, distances, and strength of their connections are not predefined to control their interactions by design. Rather, the agents develop their connections as they interact and make decisions through rounds of interactions.

Decision Rules. The three groups of the social psychological studies reviewed in this chapter imply that members' interactions play critical roles. First, members evaluate whether common understandings in an organization are effective by interacting with each other. Second, they make choices concerning speaking up and taking action while they interact with each other. The effects of these interactions reverberate at and across individual, collective, and organizational levels, constraining or provoking changes at these levels. Therefore,

agents' decision rules in the models of this dissertation must define how agents interact with other agents and make choices from the interactions. There are three decision rules in the models, the initiating rule, search rule, and change rule.

The initiating rule is a rule with which agents decide whether they speak up on a potential problem at the beginning and whether they become initiators of interactions. The search rule is a rule for agents to choose counterparts for interactions if they decide to speak up on the problem. Finally, the change rule is a rule for them to decide how to take into account the counterparts' opinions in a round of interactions. I explain the general properties of each of the rules below. Equations for the rules are explained in detail in Chapters 4 and 5 as the simulation proceeds.

Initiating Rule. If a member perceives a potential problem in his/her organization, the member may wish to speak up on the problem. Due to this motivation, such members are potential initiators of interactions. Then, the subsequent decision of such members follows the implications of the second and third groups of social psychological studies.

First, if an organization successfully encourages members to report problems, individuals who perceive potential problems will speak up on them. In an organization where speaking up is rewarded or psychologically safe, the other conditions (e.g., the match between one's expertise and the field of potential problems) will not interfere with the individual's decision.

Second, however, the rule becomes stricter as an organization becomes more like those described in the second group of studies. Thus, if an organization is less successful in encouraging members to speak up, individuals without appropriate expertise will not speak up on perceived problems. Such a deed becomes the responsibility of experts.

Third, if an organization provides far less favorable environments for speaking up, members worry about how many others share their perceptions of a potential problem. In the organization, an agent's opinion and the other agents' opinions impact the agent's decision to speak up on the problem.

These variations in the initiating rule reflect variations in conditions under which agents' opinions and expertise are important. The second and third groups of social psychological studies reviewed in this chapter support these variations. Both the second and third groups suggest that it is critical that an individual with appropriate expertise is given attention and does not need to worry about how they are perceived when they speak up. Each of the groups provides detailed information concerning when members' opinions and expertise are important. For example, when overconformity causes the groupthink (Esser 1998; Janis 1972; 1983; McCauley 1989) or "potential embarrassment" prevents bystanders from taking action (Latané and Nida 1981), individuals pay attention to others' perceptions of them and the problems. "Audience inhibition", which is another cause of the bystander effect, indicates that individuals fear other bystanders' accusations of reckless actions and worry about their credentials, i.e., expertise, to take action (Latané and Nida 1981). These examples imply that when members feel more prohibitions in terms of their expertise and others' opinions, they are less likely to speak up on a perceived problem.

Arguments of the second and third groups of social psychological studies also suggest that "speaking up" is a larger issue than advocating own opinions, especially when a question concerns difficulties in discussing potential problems. As organizational conditions become stricter against open discussions, it becomes more difficult to ask questions or even open one's mouth about the problems. As Morrison and Milliken (2000) indicate, members must

make a critical decision to break silence long before they attempt to spread their personal beliefs. In this dissertation, "speaking up" and "initiating interactions" indicate that members overcome the psychological obstacle and step forward to discuss potential problems. The initiating rule reflects these decisions and behaviors of agents. In contrast, the change rule indicates how susceptible agents are to others' opinions and how influential their opinions are to other agents.

Search Rule. The initiating rule defines when an agent decides to speak up, and the search rule defines with whom the agent interacts, in other words, with whom the agent discusses concerns. The second and third groups of social psychological studies reviewed in this chapter suggest that the power and status of potential counterparts of interactions is important to the rule. For example, studies on the groupthink and on TPS imply that members do not report problems to a leader when they fear the leader's power and status. The studies also imply that to avoid damages to their own power and status, members cannot disregard how peers and subordinates perceive them. Studies on organizational silence and on HROs imply that power and status differences are an obstacle for both front-line experts and managers.

An example of this obstacle is found in the decision-making on the night before the Challenger launch. On that night, a manager of the contractor in charge of the solid rocket booster, Morton Thiokol, switched his position from anti-launch to pro-launch when his vice president told him to put on a manager's hat instead of an engineer's hat (Presidential Commission on the Space Shuttle Challenger Accident 1986). The pressure from the vice president and the switch of his position led to the contractor's recommendation to NASA to launch the Challenger.

Based on these implications, I assume that the following variations of the search rule are appropriate. First, if an organization is open to speaking up and taking action, members who decide to initiate interactions contact others regardless of their power and status. They contact not only their superiors but also peers. They also speak to their subordinates, explain the situation, and in some cases, even ask the subordinates' opinions. In this organization, an agent interacts with all other agents regardless of their power and status.

Second, if an organization is less open than the above case, members become slightly more defensive and attempt to avoid the damages to their power and status that may be caused by discussing potential problems with their subordinates. As a result, members omit subordinates from the list of potential counterparts and contact those who have the same or higher power and status. In this organization, an agent chooses other agents as counterparts if they have the same or greater values of power and status.

Third, in an organization in which members fear negative outcomes of speaking up, they become more rigid in choosing counterparts for interactions. In such an organization, even peers can be the source of ridicule or negative judgment if a member attempts to discuss potential problems with them, which damages his/her power and status. Members attempt to fulfill the minimum responsibility by only bringing problems to their superiors' attention. In other words, an agent chooses other agents as counterparts only if they have higher power and status.

Finally, if members believe that speaking up is unacceptable in their organization, what will they do? They will only speak to peers and not inform the others of potential problems; this is the situation that theorists in the third group of social psychological studies fear. The members only whisper about their perceptions of the problems among their peers

because they consider it risky to discuss the problems with those with higher and lower power and status. As a result, no report of problems moves along the hierarchical ladder and the organization experiences organizational silence or the effect of the lack of TPS. In such an organization, an agent only chooses other agents that possess the same values of power and status as counterparts. The option to remain quiet is not available to agents in this regard because the search rule applies only to those who have decided to initiate interactions and concerns how they choose their counterparts to discuss potential problems.

Change Rule. Once an agent decides to initiate interactions and chooses counterparts for the interactions, the next decision is how to take into account the counterparts' opinions in a round of interactions. In this dissertation, the rule for the decision is called the change rule. To set the rule, social impact theory (Latané 1981), including its psychosocial law, provides useful insights into how an agent weighs the opinions held by multiple counterparts, as elaborated in Chapter 5. It is necessary to emphasize that the rule dictates how an agent changes opinion, but in the current ABM, this rule also indicates how other agents respond to the former agent's opinion. This response is possible because the other agents also make a decision depending on the same change rule. As a result, as interactions among agents proceed, agents exchange their opinions and the opinions continue to change through those interactions. Similar to the real world, every discussion is mutual and agents not only listen to others' opinions but also proclaim their opinions. The initiating rule above concerns breaking silence rather than advocating one's opinions. However, the rule, working with the change rule, does not indicate that an agent simply complies with others' opinions. Other agents also listen to the agent's opinion; thus, the agent practically advocates it through the interaction.

A Feedback Mechanism. From interactions with other agents, an agent acquires a new opinion value. If an agent's new opinion value differs from its original value, the agent is assumed to have learned by interacting with others and adjusted its understanding about the norms, beliefs, routines, shared meanings, etc., in the organization to a more common understanding. In other words, interactions with other agents successfully socialize it or help it to adapt. It is also possible that an agent develops an opinion that deviates from a common understanding through interactions. In addition, if there is no change in an agent's opinion value after a round of interactions, the agent does not learn or has been successfully socialized or adapted such that no change in its understanding is necessary.

In the models of this dissertation, an agent is assumed to achieve greater learning if the distance between its new opinion value and the mean of a distribution of opinions after a round of interactions becomes less than the distance in a previous round of interactions. This is because the mean of the distribution of agents' original opinions is considered to represent the common understanding among members in an organization. This learning defines a feedback to agents in the form of changes in their informal power and status. If an agent's opinion value becomes closer to the mean of a new opinion distribution after a round of interactions, the result generates positive feedback because the agent has learned well and is more mindful of and responsive to changes in its organization. In this case, the agents' informal power and status increases. If the distance between the new opinion value and the new mean increases, then the result generates negative feedback to an agent because the agent has not learned well and is less mindful of and responsive to changes in its organization. Thus, the agent's informal power and status decreases. If there is no change in the distance, an agent's informal power and status does not change. In other words, a feedback mechanism

in the ABM of this dissertation indicates that agents are rewarded based on their learning to be compliant with common understandings in their organization. The reward is their colleagues' greater trust in their competency and helpfulness.

The changes in agents' informal power and status are based on the discussion on power and status in this chapter. Members' power and status may increase or decrease depending on the quality of their judgments concerning the common understanding in their organizations. However, formal ranks do not change simply because a member makes a correct decision about the common understanding. On the contrary, informal power and status, which is determined by others' impressions of a member's competency and helpfulness, can change because of the quality of the member's judgment.

The feedback changes agents' behaviors in subsequent rounds of interactions. If agents' informal power and status changes, the agents initiate interactions in the next round because both negative and positive feedback can motivate them to learn more (e.g., Fiol and Lyles 1985; Herriott, Levinthal and March 1985; Levitt and March 1988; Lomi, Larsen and Ginsberg 1997; Miner and Mezias 1996; Ostroff and Kozlowski 1992; Weick 1996; Weick and Westley 1996). In contrast, agents do not join the next round of interactions if their informal power and status does not change because no positive or negative effect has occurred regardless of attempts to learn about a common understanding in their organization from other agents.

Changes in agents' power and status after interactions also change the entire power and status structure in their organization.

Controls. Social psychological studies provide many useful insights into agents' endowments for the ABM in this dissertation. Then, among these endowments, which must

be controlled in a study of the relationships between organizational decision-making and rare but salient events? On the one hand, a method of studying a phenomenon with an ABS is to swap parameter values of agents' attributes, especially those of initial conditions, at the start of each run of an ABM. Then, by comparing outcomes across models, the effects of the attributes become clear. On the other hand, the purpose of the ABS of this dissertation is to study the effects of members' interactions on organizational-level choices of action or inaction. The patterns of members' interactions are determined by organizational conditions inferred from the three groups of the social psychological studies, and those patterns are operationalized as agents' decision rules, which are described above. Thus, for the purpose of this dissertation, it is necessary to change combinations of agents' decision rules and compare outcomes of the ABM rather than to swap initial values of agents' attributes.

In addition, to identify conditions for organizational action or inaction, the method of beginning with small and simple models (i.e., the minimalist models) and testing one condition at a time is preferred for the following reasons[11].

First, by controlling the conditions of members' interactions, it becomes easier to identify which of the agents' endowments, such as different sets of decision rules, is significant in terms of their effects on organizational-level choices (e.g., Gilbert 2007; Gilbert and Troitzsch 2005; North and Macal 2007a). Second, the risks of overlooking confounding factors decrease due to the use of a controlled ABS experiment. In the ABS of this dissertation, it is unnecessary to worry about hidden variables and the spurious effects intrinsic in agents' endowments because the endowments are not based on empirical data. However, the method of running large-scale models from the beginning may paradoxically

[11] I am extremely thankful to Professor Scott F. Rockart for instruction on this essential approach to controlled experiments. The next few chapters are productive and meaningful because of his repeated emphases on the issue.

create spurious relationships between the agents' endowments and outcomes because such an approach complicates the task of dissecting all of the relationships between the endowments and outcomes. It is preferable to avoid such unexpected outcomes. In this regard, emergence from the individual to organizational level does not necessarily indicate that outcomes are surprising or unanticipated (Epstein 2006); it is more important to understand why an organizational-level outcome emerges from interactions among members.

Thus, the strategy in this dissertation is to begin with a small and simple model, to the extent that it even seems to be unrealistic, and then to scale it up as necessary (e.g., Bonabeau 2002; Macal and North 2005; Macal and North 2006; Macal and North 2007; Macy and Willer 2002). The smallest and simplest model, which I call the baseline model, has the simplest sets of agents' endowments. To and from the baseline model, varieties of agents' endowments are added, controlled, and removed one by one. With the varieties that have significant effects on the collective-level choice, the ABM grows from the minimalist model.

In the next chapter, I perform the controlled experiments on the minimalist models, beginning with the baseline model described above. In the experiments, the effects of different conditions, such as different attributes of agents and decision rules, on organizational-level choices are studied and explained in a transparent and lucid manner by swapping them one by one.

CHAPTER 4

CONTROLLED EXPERIMENTS WITH THE MINIMALIST MODELS OF MEMBERS' INTERACTIONS

In this chapter, I perform controlled experiments, beginning with the baseline model, as explained at the end of Chapter 3. The model evolves into comparatively complicated models as the experiments proceed, that is, as agents' decision rules change and relevant attributes are introduced. Table 1 in Appendix A shows the permutations of the rules and attributes for the controlled experiments in this chapter. Table 2 in Appendix A describes the details of the rules[12]. "List of Symbols" on pp. xiii-xiv summarizes the mathematical expressions and notations that appear in Chapters 4 and 5. I use Repast Simphony, a JavaScript-based simulation toolkit, to run the ABM of this dissertation.

The Baseline Model

The baseline model is the smallest and simplest model, as shown in the first row of Table 1 in Appendix A. In the minimalist models, including this baseline model, there are only three agents in the space, Member 1, 2, and 3. The triad is necessary to examine the effects of different conditions on collective-level choices, for example, by calculating the mean of their opinion values or by controlling distributions of their attributes. To maintain identical initial conditions across different models, the agents' locations in the space are fixed in Repast Simphony. In addition, the three agents have a fixed distribution of opinions, which is $O_i = \{0.5, 0.0, 0.5\}$, where O_i is an agent's opinion value before a round of interactions and

[12] I am very thankful to Professor Catherine Zimmer for her detailed advice on the readability and presentation of Chapters 4 and 5 as well as her invaluable advice on other points.

$i = \{1, 2, 3\}$ is the number of agents. The three values of agents' opinions are selected to simplify the explanation of what occurs in the ABS. In the baseline model, the agents' decision rules are simplest. All of the agents begin interactions without considering any other conditions, such as their expertise or power and status, which is Initiating Rule 1 in Table 2 in Appendix A. Then, they interact with each of the two other agents, which is Search Rule 1 in the table. Finally, they calculate the arithmetic mean of all agents' opinions including their opinion and adopt the arithmetic mean as their opinion after a round of interactions, which is Change Rule 0A in the table.

This smallest and simplest model produces a clear outcome and, thus, can serve as the baseline for subsequent controlled experiments. As Figure 4.1 shows, interactions among the three agents quickly lead to an agreed choice at the collective level, approximately 0.33, which is the arithmetic mean of opinion values of each of the agents. In the figures in this chapter, including Figure 4.1, ticks on the x-axis indicate rounds of interactions.

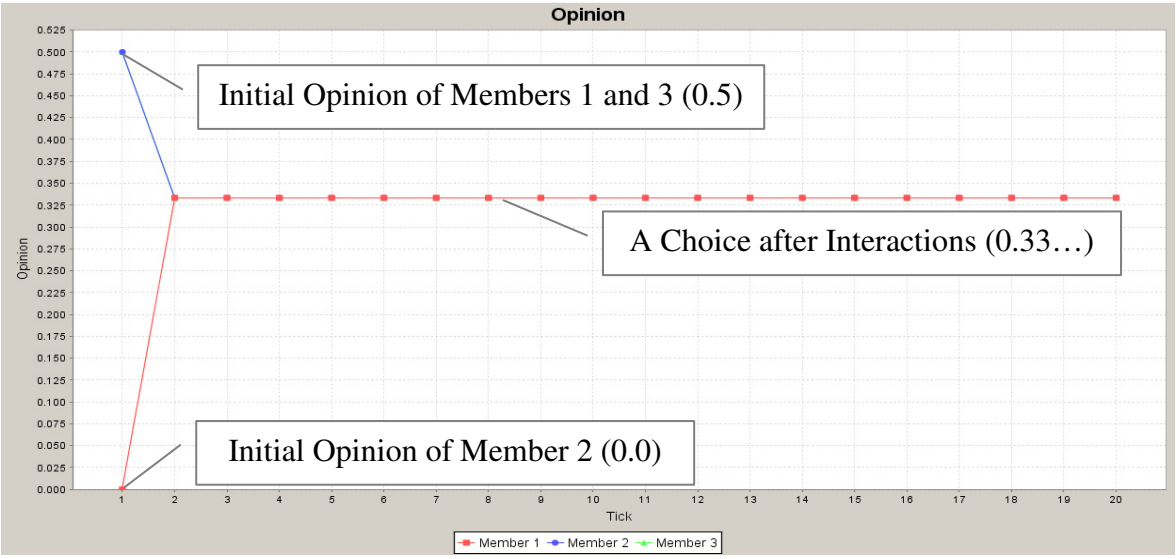

Figure 4.1 Outcome of the Baseline Model

The opinion value after a round of interactions is also a common understanding among agents under the simplest condition. In the controlled experiments in this chapter, agents'

greater opinion values are considered more pro-action than lesser values. Thus, 0.5 is more pro-action than both 0.0 and 0.33. The mean value of 0.33 simply suggests that under the simplest condition of the baseline model, agents' interactions generate a collective-level choice with a pro-action level that is less than 0.5 but more than 0.0.

In the baseline model, agents do not consider their characteristics, for example, whether they have expertise that is appropriate to the field of potential problems. Then, what changes occur to the collective-level choice if agents pay attention to their qualifications to speak up?

"Match of Expertise" and Changes in the Initiating Rule and Change Rule

The social psychological studies reviewed in Chapter 3 imply that as organizations become less open to speaking up on and taking action against potential problems, members begin to worry about whether it is safe or appropriate for them to discuss those problems. One factor that intervenes in their decision to speak up is the match between their expertise and the field of potential problems. In this experiment, the three agents are assigned a binomial value, 1 = match between the expertise and the field of potential problems and 0 = no match. Their decision rules, especially the initiating rule and change rule, accordingly change. Now, they initiate interactions with other agents only if their expertise matches the field, which is Initiating Rule 2 in Table 2, and pay greater attention to experts' opinions than non-experts' opinions, which is Change Rule 0B in the table. In other words, their opinion values after interactions are no longer the simple arithmetic mean, but a weighted mean in which experts' opinions are weighed, for example, twice as much as non-experts' opinions, as shown below:

Change Rule 0B: $AO_i = \left(O_i * IO_i + \sum_{ci=1}^{CI}(O_{ci} * IO_{ci})\right)/\left(CI * \sum_{ci=1}^{CI} IO_{ci} + 1 * IO_i\right)$, where AO_i is an agent's opinion values after a round of interactions, IO_i is the impact of an agent's opinion value, O_{ci} is a counterpart's opinion value, IO_{ci} is the impact of a counterpart's opinion value, $E = 1 \Leftrightarrow IO = 2$ whereas $E = 0 \Leftrightarrow IO = 1$, and E is agents' match of expertise.

Surprisingly, under the above condition, the collective-level choices of action or inaction against potential problems depend on the opinion values of non-experts rather than those of experts. Figure 4.2 shows the outcome when the distribution of agents' expertise is $E_i = \{0, 1, 0\}$, where E_i is an agent's match of expertise, and Figure 4.3 shows the outcome when the distribution is $E_i = \{1, 0, 1\}$. As Figure 4.2 shows, when the choices are action, collective opinion values among agents eventually converge toward 0.5 from $O_i = \{0.5, 0.0, 0.5\}$, which are the initial opinion values of non-experts. When the choices are inaction, the values eventually converge toward 0.0 from $O_i = \{0.5, 0.0, 0.5\}$, as Figure 4.3 shows. This is the initial opinion value of Member 2, who is the only non-expert among the three agents.

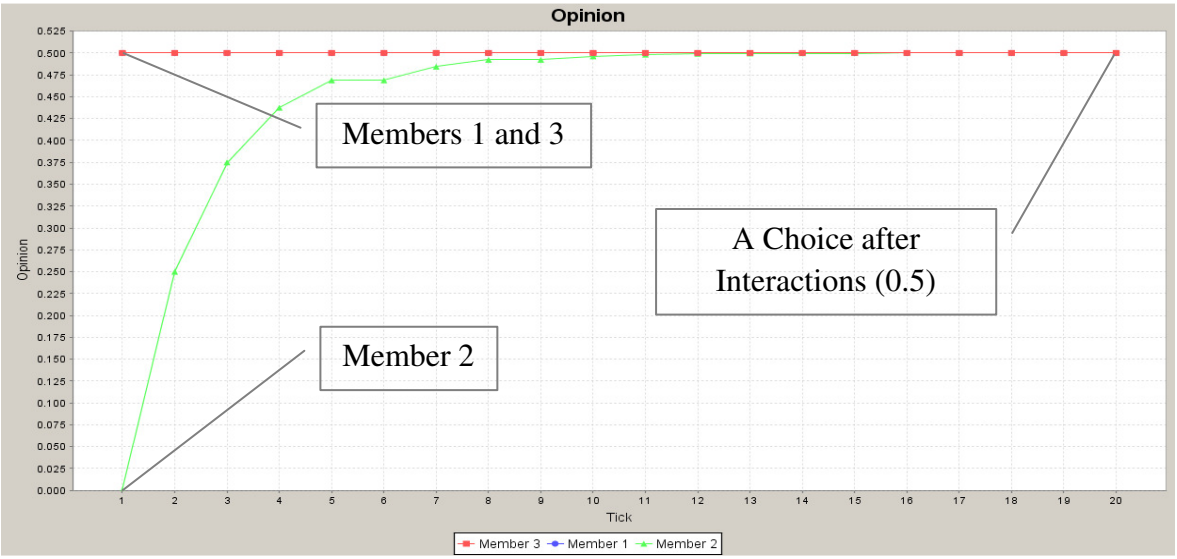

Figure 4.2. Outcome with $E_i = \{0, 1, 0\}$

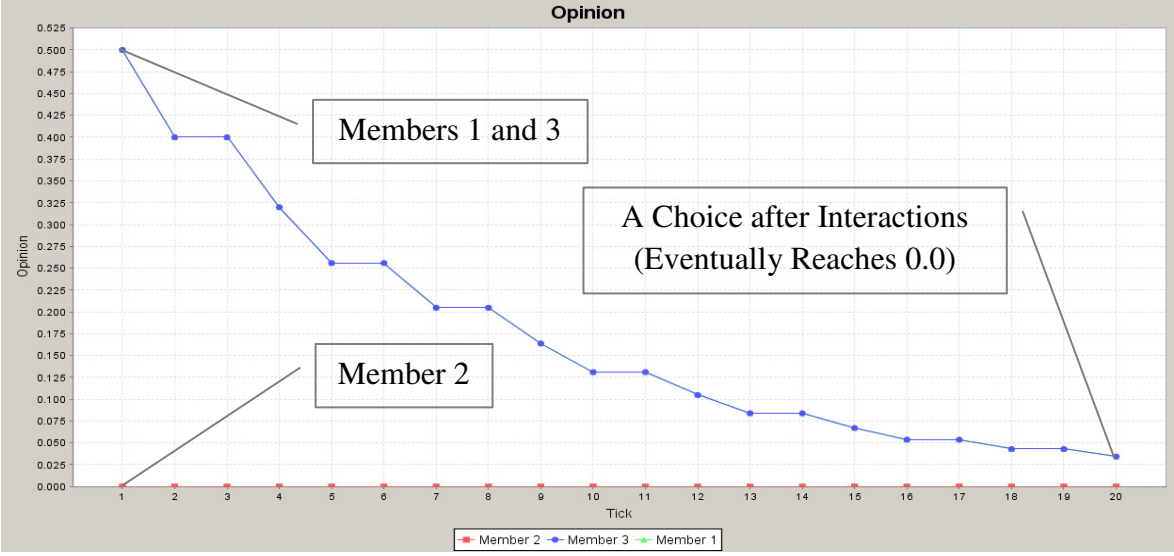

Figure 4.3. Outcome with E_i = {1, 0, 1}

These outcomes occur because experts under the condition are open-minded and take into account non-experts' opinions, although these opinions have less weight than the experts' opinions. If experts disregard non-experts' opinions, that is, their search rule is not Search Rule 1, no changes occur in the opinion distribution at the collective level. If none of the agents is an expert, no changes occur in the distribution because no one initiates interactions due to Initiating Rule 1. If all of the three agents are experts, all of them initiate interactions. As a result, the collective-level choice becomes the same as that in the baseline model regardless of Initiating Rule 2. In this case, the distribution of agent expertise does not have significance in terms of the collective-level choices. When there are both experts and non-experts in an organization and experts pay attention to non-experts' opinions, non-experts determine organizational action or inaction. In other words, non-experts' opinions become influential when (1) organizational conditions become less favorable to speaking up and taking action, which limits those who initiate interactions to experts, and (2) in spite of the limitation, experts are not selective in terms of their counterparts. Although experts weigh

other experts' opinions more than non-experts' opinions, following Change Rule 0B, the difference in the weight does not cancel the influence of non-experts' opinions.

The above outcomes have an interesting implication about organizational conditions for members' interactions. In an organization in which conditions, or the atmosphere, are not favorable for speaking up on potential problems, experts' voicing on the problems helps to develop organizational-level choices that conform to the opinions of those who do not speak up. In the organization, non-experts do not initiate discussions because organizational conditions are not favorable for them to do so. However, regardless of their opinions, by being cautiously silent and entrusting experts with the risky business of speaking up, their belief is realized as an organizational choice. For experts who prefer action against potential problems, this outcome seems to be uncomfortable. Unless non-experts also prefer action, organizational-level choices shift toward inaction as members continue to discuss on what to do against potential problems.

What occurs, then, if the opinions of non-experts split into action and inaction? In this case, the organization is stuck in a perpetual state of collective disagreement. Figure 4.4 on the next page shows such an outcome. In this case, only Member 1 is an expert and the other members have two different opinions, action (0.5) and inaction (0.0). Member 1 takes into account all of the opinions through rounds of interactions. Thus, although its opinion weighs more than the two non-experts' opinions, the value of the opinion decreases and it eventually reaches the simple mean of the two non-experts' opinions. As a result, no convergence of opinions occurs at the collective level and members reach no agreement even if they continue to discuss on what to do against potential problems.

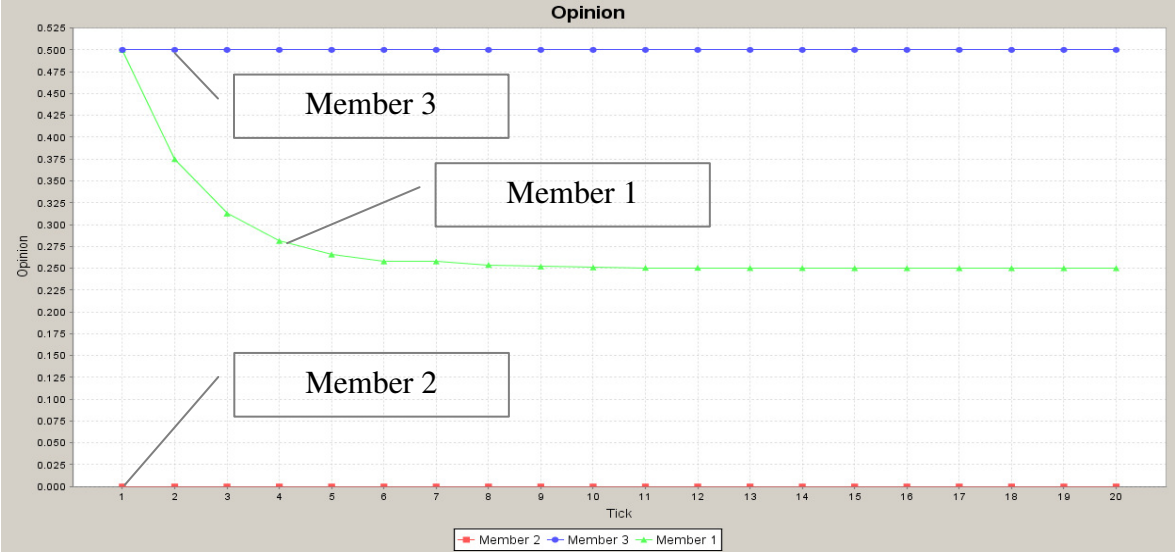

Figure 4.4. Outcome with E_i = {1, 0, 0}

In these models, agents are not selective in terms of their counterparts for interactions because of Search Rule 1. However, in an organization, members are formally and informally rank-ordered according to their power and status, as the social psychological studies suggest. Members may choose their counterparts based on differences in power and status. In the next section, the focus of the experiment is this aspect of members' interaction patterns and its effects on the collective-level choices.

"Power and Status" and Changes in the Search Rule and Change Rule

In Chapter 3, I have inferred from the social psychological studies that members limit their counterparts based on power and status as organizational conditions become less favorable to speaking up and taking action. At the beginning, they exclude individuals with lower power and status from discussions on potential problems because they fear appearing incompetent to such members and giving the members opportunities to ridicule them. This exclusion occurs in organizations that lack trust relationships between leaders and subordinates and among peers, as studies on TPS suggest. In this dissertation, the exclusion leads to Search Rule 2 in Table 2 with which agents select other agents with the same or

higher power and status. Then, they only discuss the problems with individuals with higher power and status, which is Search Rule 3. Under this condition, members with the same power and status are excluded from discussions because of the same fear for which agents exclude those with lower power and status. In other words, members attempt to control possible damages by fulfilling minimum responsibilities in their organization; they deliver their concerns only to superiors or those who are considered more reliable. Finally, they limit their interactions with those who have the same power and status as a form of risk avoidance, which studies on organizational silence imply. Under this condition, members are worried that even fulfilling minimum responsibilities may harm them and simply whisper their concerns among peers.

To examine what occurs to collective-level choices if agents select their counterparts in these manners, I distribute two values of power and status[13], 1 and 2, across Members 1 to 3 and switch agents' decision rules, specifically their search rule, one by one. With the two values of power and status, the agents have counterparts whose power and status is lower than, the same as, or higher than their power and status. In addition, with different search rules, agents now select different counterparts based on the values of power and status as organizational conditions become more difficult to speak up and take action. Agents' change rule also changes into Change Rule 0C as shown below:

Change Rule 0C: $AO_i = \left(O_i * IO_i + \sum_{ci=1}^{CI}(O_{ci} * IO_{ci})\right)/\left(CI * \sum_{ci=1}^{CI} IO_{ci} + 1 * IO_i\right)$, where $PS_{ci} > PS_i \Leftrightarrow IO_{ci} = 2, PS_{ci} = PS_i \Leftrightarrow IO_{ci} = 1, PS_{ci} < PS_i \Leftrightarrow IO_{ci} = 0.5$, PS_{ci} is a counterpart's power and status, and PS_i is an agent's power and status.

[13] These values of agents' power and status are temporary for the minimalist models. In Chapter 5, different equations are used.

In other words, agents weigh the opinions of counterparts with higher power and status as twice the amount of their opinion and those of counterparts with lower power and status as half of their opinion. When counterparts have the same power and status, agents weigh their opinions as equal to their own opinion, which is with the weight of 1. However, in these models, agents' initiating rule returns to Initiating Rule 1, as in the baseline model, and all of the three agents initiate interactions. The rule applies because they do not have the attribute that differentiates initiators from non-initiators, match of expertise. Due to Change Rule 0C, it is predictable that as an agent's power and status increases, its opinion becomes more influential. Outcomes of the simulation support this prediction in some cases, but there are exceptions, as follows.

In most cases of this experiment, collective-level choices depend on the opinion values of agents with higher power and status. Whether agents select counterparts with both the same and higher power and status or limit counterparts to those with higher power and status only, the opinions of agents with lower power and status shift toward those of agents with higher power and status. As a result, depending on the opinion values of agents with higher power and status, collective-level choices become action or inaction against potential problems. As shown in Figures 4.2 and 4.3, when the choices are action, agents' opinion values eventually converge to 0.5 and when the choices are inaction, the opinion values converge to 0.0. In Table 1 in Appendix A, these outcomes emerge in ABMs 6, 8, 9, 10, 12, and 13, in which collective-level choices are identical to the initial opinion values of agents with higher power and status, which is 2.

In the previous section, one of the outcomes is a perpetual state of collective disagreement. The same outcome emerges in the experiment in this section even though all

agents initiate interactions. That case is ABM 11 in Table 1, in which PS_i = {1, 2, 2}. In this case, all agents initiate interactions, following Initiating Rule 1, but only an agent with the lower power and status, Member 1, interacts with the other two agents that possess higher power and status due to Search Rule 3. In addition, because of Change Rule 0C, the agent weighs other agents' opinions twice as much as its opinion. As a result, Member 1's opinion changes from 0.5 to 0.3 in the first round of interactions and it eventually reaches 0.25, as Figure 4.5 shows. The value is equal to the weighted mean of all of the three agents' opinions.

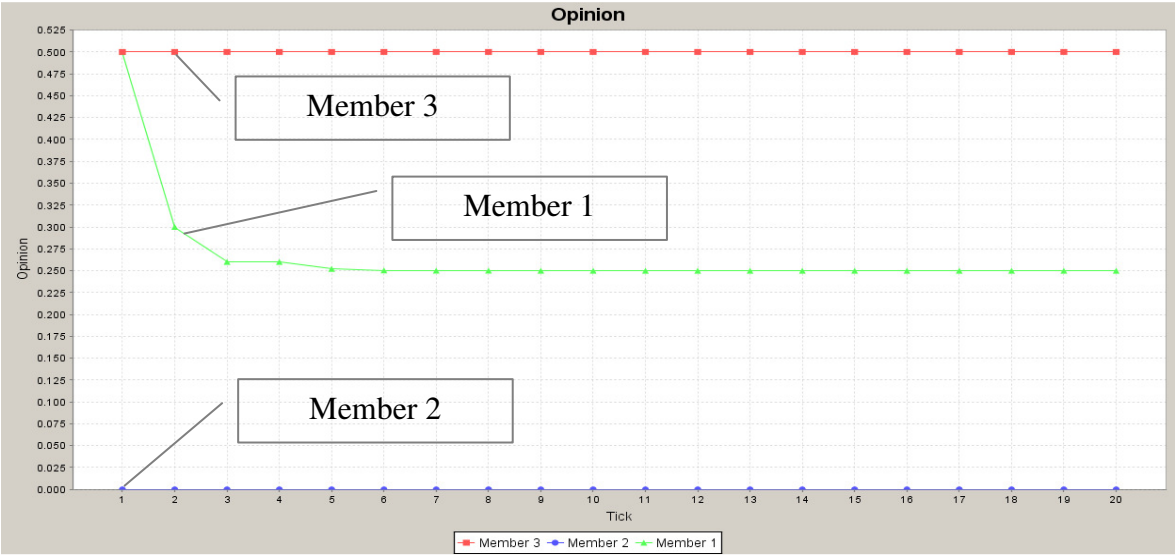

Figure 4.5. Outcome with PS_i = {1, 2, 2}

In contrast, although the agents with higher power and status, Members 2 and 3, follow the same decision rules, they do not interact with the other agents and, thus, their opinions do not change. Because of this inaction, the three agents' opinions do not converge and the organization is stuck in the perpetual state of collective disagreement similar to Figure 4.4.

The similarity between Figures 4.4 and 4.5, that is, the similarity of outcomes between ABM 2 and ABM 11 in Table 2, suggests that there is a commonality between the effects of agents' power and status and their expertise. The agents' opinion values after interactions are the same if the distributions of agents' power and status are similar to those

of agents' expertise and if agents select counterparts with the same or higher power and status or only with higher power and status. For example, in addition to the above two models, the collective-level choice is 0.5 in ABM 3, in which $E_i = \{0, 1, 0\}$, and ABMs 9 and 13, in which $PS_i = \{2, 1, 2\}$. The same outcome also emerges in ABM 4, in which $E_i = \{1, 1, 0\}$, and ABMs 6 and 10, in which $PS_i = \{1, 1, 2\}$. Although the distributions of agents' expertise and their power and status are not identical in the two groups of ABMs, the effects of the attributes are similar. As agents' opinions shift toward those of non-experts, their opinions move toward those of agents with higher power and status. The same pattern exists in ABM 5, in which $E_i = \{1, 0, 1\}$, and ABMs 8 and 12, in which $PS_i = \{1, 2, 1\}$. In other words, the higher power and status of agents has the same effect on collective-level choices as the lack of match between agents' expertise and fields of potential problems. In the previous section, experts' opinions shift toward those of non-experts. These non-experts do not initiate interactions. However, experts who are the initiators include these non-experts into discussions of potential problems; thus, they take into account the non-experts' opinions. As a result, the opinions of non-experts determine collective-level choices even though the non-experts do not begin the discussions.

In this section, initiators' opinions shift toward those of agents with higher power and status. In the models, all agents become initiators, but not all of them are as open-minded as the experts in the previous section. For example, if only one agent has the value of power and status of 2 and if the search rule in the model is to only select counterparts with higher power and status, the agent does not take into account the other two agents' opinions. However, in this case, the value of the other two agents' power and status is 1 and they select the above agent as their counterpart for discussions of potential problems. As a result, through rounds

of interactions, their opinions become closer and closer to the opinion of the agent who disregards their opinions.

These relations between initiation of interactions and selection of counterparts suggest that even if members feel safe discussing potential problems regardless of their qualifications, the collective-level choices are the same as those made in organizations without the safety if power and status differences intervene in their counterpart choices. It appears as though the safety is ritualistic or superficial, as all can speak up, but not all of the opinions are seriously heard. The only difference between the two types of organizations is who has greater influence in the discussion. On the one hand, in organizations in which expertise dictates members' decisions to initiate interactions under the conditions noted earlier, those who lack the expertise are likely to determine organizational-level choices of action or inaction, as in the models in the previous section. On the other hand, in organizations in which power and status structure controls members' counterpart choices, the opinions of those who have higher power and status are decisive.

However, the above commonality of the effects of the two attributes is lost in the following two cases. One such case is ABM 7. In this model, the collective-level choice is a convergence of all agents' opinions to 0.25. The distribution of agents' power and status of the model is $PS_i = \{1, 2, 2\}$, and agents select counterparts with the same or higher power and status, which is Search Rule 2. The distribution of agents' power and status is comparable to $E_i = \{1, 0, 0\}$ and, thus, with Search Rule 2, the outcome should be a perpetual state of disagreement, as in ABM 2 and ABM 11. Despite these conditions, the collective-level choice does not follow the same mechanism as that of the two ABMs. The other case occurs when agents' search rule is Search Rule 4, that is, they only select counterparts with

the same power and status. These models are ABMs 14 to 17 in Table 1. In these models, the majority choices of an opinion value of 0.25 or 0.5 emerge as collective-level choices regardless of the distributions of agents' power and status. These outcomes are interesting for the following reasons. First, they may suggest effects of agents' power and status that differ from those of their match of expertise in spite of the similarity of their roles to determine organizational-level choices as discussed above. Second, because of the first reason, the outcomes may suggest how different organizational conditions change organizational-level choices, especially when the conditions become less favorable to speaking up on and taking action against potential problems.

The first case, ABM 7, violates the commonality of the effects but is compatible with the finding on the relationship between initiations of interactions and selection of counterparts. As Figure 4.6 shows, Member 1 selects the other two members with higher power and status, whereas Members 2 and 3 select each other as counterparts. As a result, the collective-level choice under this condition becomes the mean value of the opinions of Members 2 and 3, which is 0.25. Thus, although all agents initiate interactions, following Initiating Rule 1, the opinions of agents with higher power and status determine the collective-level choice of inaction, as occurred in other ABMs. The violation of the commonality that occurs in ABM 7 leads to two questions. First, why does the violation occur in ABM 7 but not in ABMs 2 and 11? Second, why does it not occur in other ABMs with the same set of decision rules as the rules in ABM 7, that is, ABMs 6, 8, and 9?

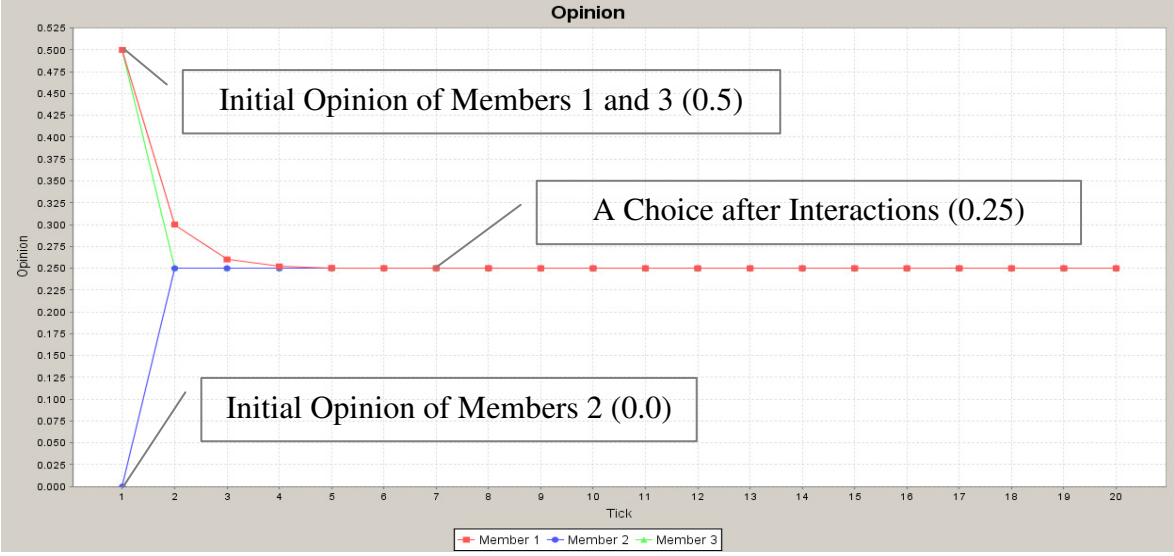

Figure 4.6. Outcome with PS_i = {1, 2, 2} and
Counterparts with the Same or Higher Power and Status

The first question highlights the relationship between initiators and collective-level choices. In ABM 7, agents follow Initiating Rule 1 and Search Rule 2; thus, all three agents initiate interactions and have counterparts to change their opinions, following Change Rule 0C. As explained in the above paragraph, this is the reason that the collective-level choice becomes 0.25 in contrast to the perpetual state of disagreement in ABMs 2 and 11. In the latter two models, only one agent, Member 1, becomes an initiator and changes its opinion. In ABM 2, the agents follow Initiating Rule 2, which limits initiators to experts. Although Search Rule 1 allows them to select any other agents to discuss potential problems, the two non-experts, Members 2 and 3, do not select other agents. In ABM 11, Initiating Rule 1 allows them to initiate interactions but Search Rule 3 dictates them to select other agents as counterparts only if they have higher power and status than the self. As a result, in this model, only Member 1, whose value of power and status is 1, seeks the other two agents' opinions. The difference in the number of initiators and collective-level outcomes suggests that as more members are involved in decision-making, a consensus becomes easier. In other words,

democratic organizations enable members to make coordinated moves more easily than do less democratic organizations, regardless of whether the moves are action against potential problems. In addition, this relationship between initiators and collective-level outcomes holds even if (1) the distributions of initial values of agents' attributes are constant and (2) non-experts or members who have higher power and status constantly determine collective-level outcomes.

The second question, regarding inconsistencies among ABMs 6 to 9, concerns differences in opinions among those who are influential in determining collective-level outcomes. In ABM 7, the opinions of agents with higher power and status differ from each other. The opinion of Member 2 is 0.0, whereas that of Member 3 is 0.5. On the contrary, in ABMs 6, 8, and 9, the opinions of those who are influential are the same, as Table 1 in Appendix A shows. Because influential members share the same opinions, collective-level choices become consistent with those opinions in the three models. With the relationship between the number of initiators and collective-level choices, this cause of the inconsistencies across the ABMs presents two points. First, when influential members have different opinions on what to do against potential problems, collective-level outcomes become either a perpetual state of disagreement or the mean of those opinions. Second, the outcomes that emerge from members' interactions depend on whether the organization is democratic.

Then, what occurs when agents follow Search Rule 4, as in ABMs 14 to 17, that is, when they select other agents only with the same power and status? In this case, collective-level choices become majority choices of either 0.25 or 0.5. Figure 4.7 shows how the choice of 0.25 emerges and Figure 4.8 shows how that of 0.5 emerges. In the latter figure, no

changes of agents' opinions occur, which is because agents follow Initiating Rule 1 and Search Rule 4. Thus, a majority choice of 0.5 emerges from members' interactions.

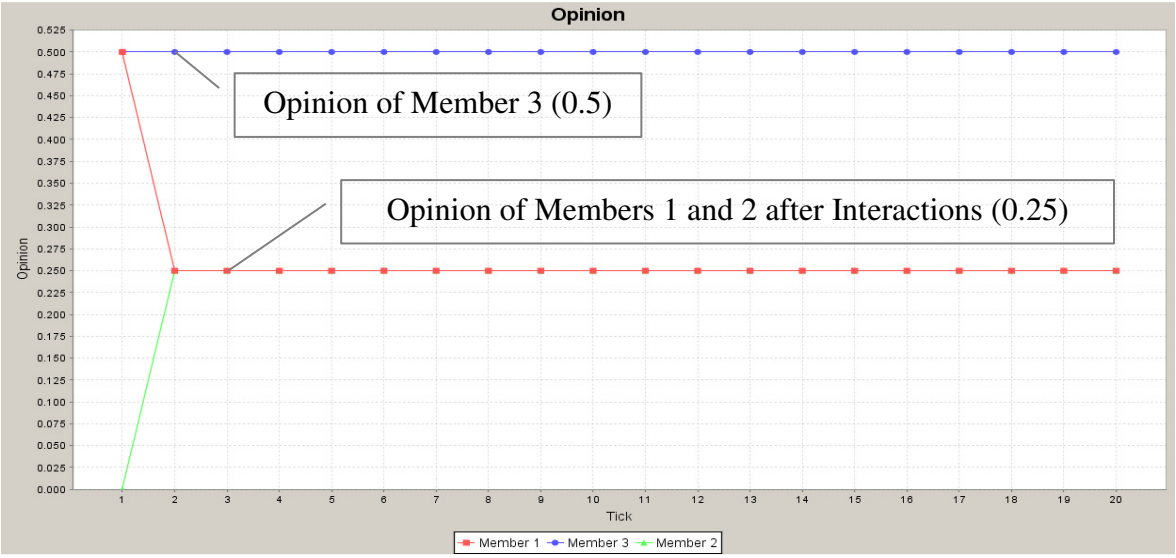

Figure 4.7. Outcome of ABMs 14 and 15 with Search Rule 4

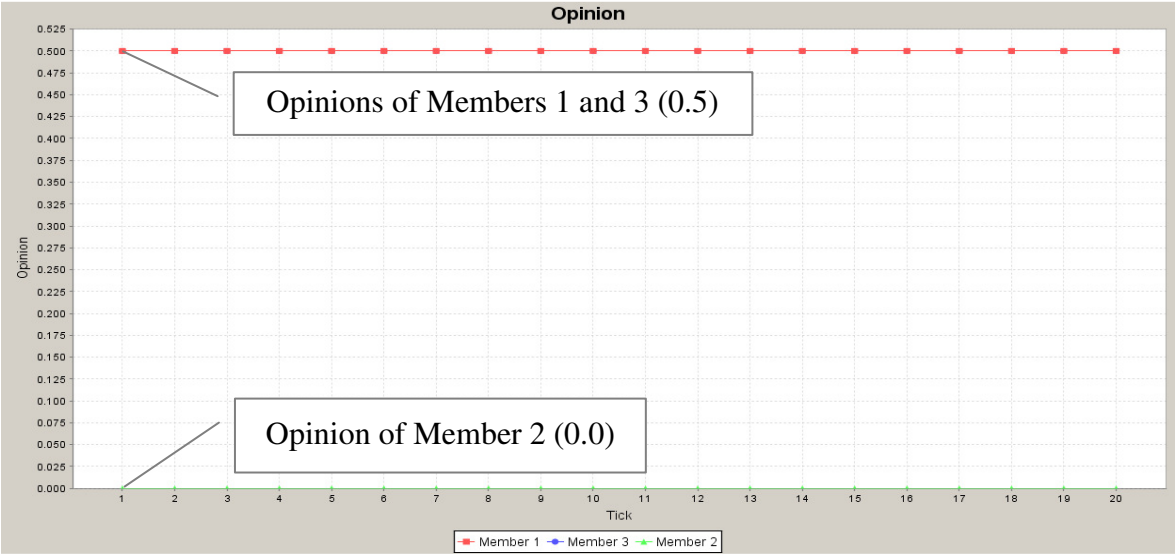

Figure 4.8. Outcome of ABMs 16 and 17 with Search Rule 4

The majority choice of 0.25 in Figure 4.7 occurs when PS_i = {1, 1, 2} and {1, 2, 2}, as Table 1 shows. Agents' opinions are fixed to O_i = {0.5, 0.0, 0.5}, as in other ABMs. In addition, with Search Rule 4, agents only select counterparts with the same power and status. Thus, it is clear that the outcome is the mean of the opinions of agents with the same power

and status and that whether these agents have higher power and status than others is unimportant. The same mechanism results in the majority choice of 0.5 in Figure 4.8. In ABMs 16 and 17, the distributions of agents' power and status are PS_i = {1, 2, 1} and {2, 1, 2} and the choice is the mean of opinions of agents with the same power and status. In other words, when agents select counterparts with the same power and status, the opinion values of agents with higher power and status do not determine the collective-level choices. Rather, the choices depend on the opinion values of agents with the same power and status. However, if an agent is not involved in interactions because its power and status is higher or lower than that of others, its opinion does not change; thus, only partial convergence of opinions occurs under these conditions.

These outcomes also suggest that when organizational conditions are least favorable to speaking up and taking action, members' discussions split them into the majority and the minority rather than resulting in collective-level agreements. In the summary of agents' endowments in Chapter 3, members are assumed to limit their counterparts to those who have the same power and status when they feel least safe. Because they worry that subordinates and peers may ridicule them or higher-ups may negatively sanction them, they simply whisper their concerns with their peers and do not reach out to others to determine what to do on those concerns or discuss problems with higher-ups. As a result, some agreements develop among the peers, but as an organization, no common understanding develops concerning what to do against potential problems.

Then, what occurs to collective-level choices when only experts initiate interactions and they are selective in terms of their counterparts? In other words, what collective-level outcomes emerge if both attributes of agents' match of expertise and power and status are

introduced at the same time along with relevant decision rules? I predict that when distributions of match of expertise and power and status are similar, such as $E_i = \{0, 1, 0\}$ and $PS_i = \{2, 1, 2\}$, collective-level outcomes are the same as those in the previous and current section. This prediction is possible because it has become clear that similar collective-level outcomes emerge in ABMs with similar distributions of agents' match of expertise and power and status. Thus, in the next section, I create the conditions under which outcomes beyond the prediction may emerge. For example, in ABM 7, agents' opinions converge to 0.25, with $PS_i = \{1, 2, 2\}$. Thus, in the next section, the distribution of agents' expertise $E_i = \{1, 0, 0\}$ is not combined with the distribution of the power and status. ABMs 18 to 26 in Table 1 in Appendix A show the permutations of the two attributes' distributions.

With regard to the decision rule, agents make their choices in the next section as follows. All decision rules mentioned in this and the next paragraph are described in Table 2 in Appendix A. First, following Initiating Rule 2, they initiate interactions if they have expertise that matches the fields of potential problems. Second, they select their counterparts based on the counterparts' power and status. In some cases, the counterparts have the same or higher power and status, with Search Rule 2. In other cases, only those with the same power and status are selected due to Search Rule 4. Search Rule 3 is disregarded in the next section because no major differences in collective-level outcomes emerge between models with Search Rule 2 and those with Search Rule 3. For example, in Table 1, each set of ABMs 6 and 10, 8 and 12, and 9 and 13 shares the same distributions of agents' power and status and the same outcomes of interactions. Outcomes in ABMs 7 and 11 differ in spite of the similar distributions of agents' power and status, but the causes of the difference have been explained. In other words, it does not seem to be worthwhile to replicate those conditions in

the next section. On the contrary, outcomes strikingly differ between ABMs 6 to 9 with Search Rule 2 and ABMs 14 to 17 with Search Rule 4. Due to these differences, it is worthwhile to compare outcomes from ABMs with the two search rules in the next section.

Third, agents weigh the opinions of experts and those with higher power and status following Change Rule 0D below:

Change Rule 0D: $AO_i = \left(O_i * IO_i + \sum_{ci=1}^{CI}(O_{ci} * IO_{ci})\right)/\left(CI * \sum_{ci=1}^{CI} IO_{ci} + 1 * IO_i\right)$, where $IO_i = \{2, 1\}$ and $IO_{ci} = \{4, 3, 2, 2.5, 1.5\}$.

The values of IO_i and IO_{ci} are based on the combinations of weights determined by agents' match of expertise and power and status, consistent with those in Change Rules 0B and 0C. Agents weigh (1) the opinions of experts and those with higher power and status twice as much as the opinions of others, (2) the opinions of those who lack expertise with the weight of 1, (3) the opinions of those with the same power and status with the weight of 1, and (4) the opinions of those with lower power and status as half of their opinion.

"Match of Expertise", "Power and Status", and Decision Rules Relevant to These Attributes

As discussed above, it is not surprising that the outcomes of the experiment in this section are the combined effects of the two attributes and relevant decision rules. In other words, the opinions of those who are non-experts and have higher power and status determine collective-level choices in most cases. Agents' search rule and distributions of agents' power and status control the outcomes of their interactions. On the contrary, the distributions of expertise that determine who become initiators do not have an impact when the distributions of power and status are controlled. The mechanisms behind these outcomes are the same as those explained in the previous two sections on the effects of each of the agents' attributes and relevant decision rules. For example, in ABM 22, in which $E_i = \{1, 1,$

0}, PS_i = {1, 2, 2}, and agents select counterparts with the same power and status following Search Rule 4, the collective-level choice is pro-action, as Figure 4.9 shows.

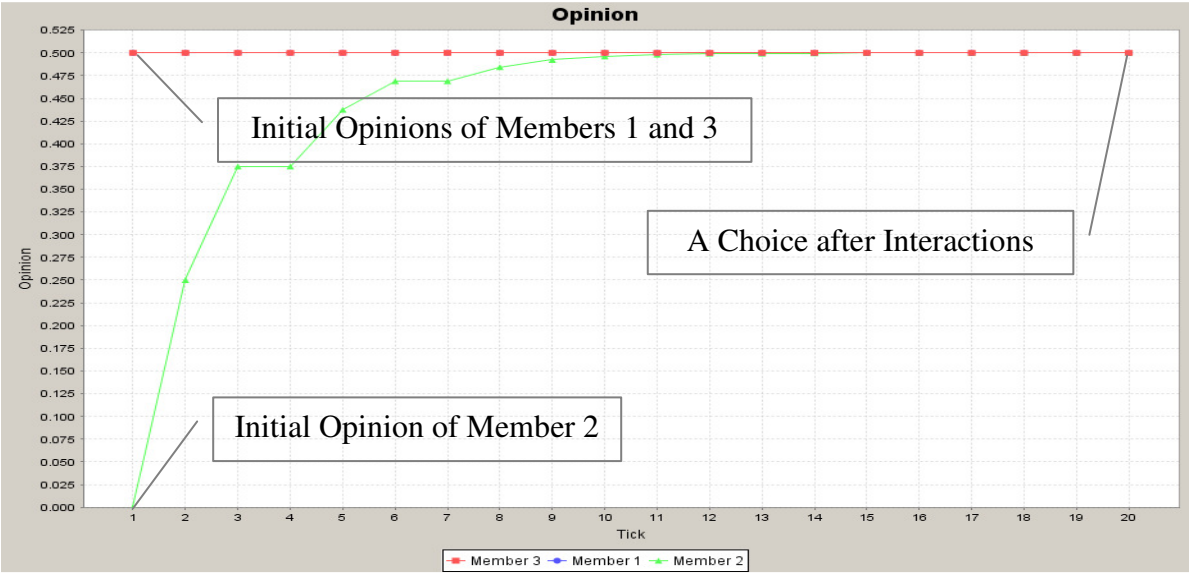

Figure 4.9. Outcome with E_i = {1, 1, 0}, PS_i = {1, 2, 2}, and Counterparts with the Same Power and Status

Under this condition, Members 1 and 2 become initiators. Because of the search rule, Member 2 selects Member 3 as its counterpart and their interactions cause the opinion value of Member 2, 0.0, to converge to that of Member 3, 0.5. However, Member 1 does not interact with a counterpart; thus, its opinion value remains at 0.5. As a result, the outcome is the collective choice of action against potential problems. In short, the opinion value of a non-expert with higher power and status, Member 3, determines the collective outcome.

The same relations between collective-level choices and agents' attributes also appear when Member 2 is the only expert and has higher power and status than the other members. However, in this case, the choices are inaction rather than action because the agent's opinion value before interactions is 0.0. For example, Figure 4.10 shows what occurs in ABM 23, in which E_i = {1, 0, 1}, PS_i = {1, 2, 2}, and agents follow Search Rule 4. Under this condition, Members 1 and 3 become initiators and Member 3 selects Member 2 as its counterpart.

Through their interactions, the opinion value of Member 3 becomes 0.0. However, the opinion value of Member 1, who has no counterpart, remains at 0.5. Consequently, the outcome is the majority choice of inaction, 0.0.

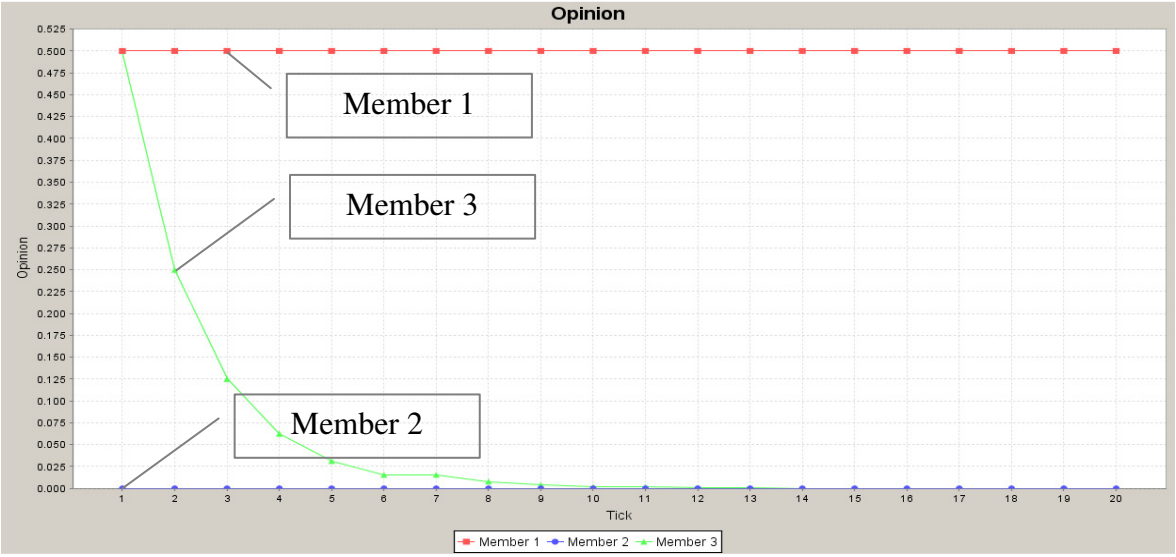

Figure 4.10. Outcome with E_i = {1, 0, 1}, PS_i = {1, 2, 2}, and Counterparts with the Same Power and Status

Even if agents select counterparts with the same or higher power and status, the above relationships do not change. Figure 4.11 shows the outcome of ABM 20, in which E_i = {1, 0, 1}, PS_i = {1, 2, 2}, and agents select counterparts with the same or higher power and status, following Search Rule 2. In this model, the collective-level choice of inaction, 0.0, emerges through interactions as follows. First, Members 1 and 3 initiate discussions of potential problems. Because they select counterparts with the same or higher power and status, Member 1 interacts with Members 2 and 3, whereas Member 3 selects Member 2 as its sole counterpart. In contrast, Member 2 initiates no discussions and its opinion remains at its original value of 0.0 due to Initiating Rule 2. Through interactions, the opinions of the initiators, Members 1 and 3, shift toward the opinion of Member 2, which produces the collective-level choice of inaction.

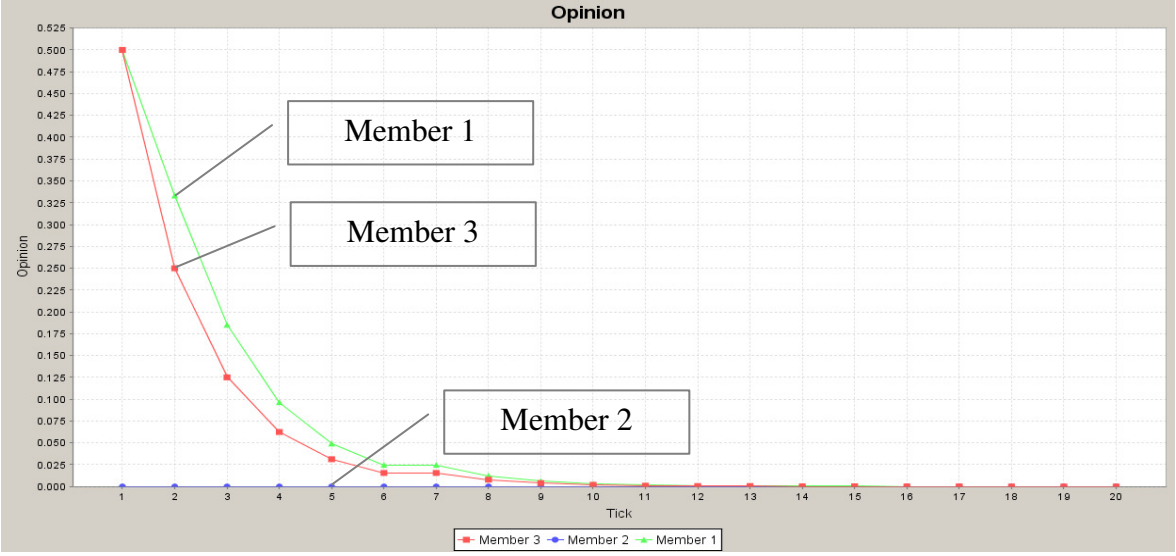

Figure 4.11. Outcome with E_i = {1, 0, 1}, PS_i = {1, 2, 2}, and Counterparts with the Same or Higher Power and Status

All of the above outcomes emerge under the condition of PS_i = {1, 2, 2}. When the distribution of agents' power and status differs and agents select counterparts with the same power and status, following Search Rule 4, different collective-level choices emerge, with no changes in the opinion distribution or the majority choice of action. Such cases include ABMs 24 to 26 in Table 1, in which the distribution of agents' power and status is PS_i = {2, 1, 2}. As discussed in the previous section, the distribution of agents' match of expertise similar to that of agents' power and status is not replicated in this section. Thus, the combinations of PS_i = {2, 1, 2} and three sets of distributions of agents' expertise, E_i = {1, 0, 0}, {1, 1, 0}, and {1, 0, 1} are examined, but the distribution of E_i = {0, 1, 0} is not examined.

Under the above conditions, Member 2 is always excluded from interactions regardless of the distribution of E_i (i.e., regardless of Initiating Rule 2) because the agent does not have a counterpart with the same power and status. As a result, no opinion changes occur through interactions between Members 1 and 3, who share the same opinion value, 0.5,

and the opinion of Member 2 remains at its original value of 0.0. In these cases, the opinions of non-experts with higher power and status do not determine collective-level outcomes. Rather, the distribution of agents' power and status and relevant agents' decision rule determine the outcomes.

Summary of the Findings of the Minimalist Models

In this chapter, I have examined how collective-level choices emerge from agents' interactions under the simplest conditions. Although the ABMs for this purpose have minimal characteristics, controlled experiments in this chapter have led to several findings that are interesting and appropriate for guiding further experiments, which are presented in Chapter 5. This section summarizes those findings.

The primary finding from the minimalist models is that collective-level choices of action or inaction depend on the beliefs of non-experts and members with higher power and status. If they believe that action is necessary against potential problems, collective-level choices for action tend to emerge. Otherwise, the choices tend to be inaction. This influence of non-experts and those with higher power and status is more conspicuous when organizational conditions are less favorable to speaking up on and taking action against potential problems. For example, when organizational conditions limit initiators to experts, the conditions do not help them to realize their beliefs. On the contrary, the conditions empower non-experts who do not initiate discussions because initiators, that is, experts, communicate with them for decision-making. When members become selective in terms of the counterparts with whom to discuss potential problems, those with higher power and status begin to influence other members' decisions, similar to non-experts in the previous example. Under this condition, members are less open-minded than the experts in the example.

Collective-level outcomes tend to be a lack of consensus on what to do against potential problems if an organization is less democratic and those who are influential possess different opinions.

The influences of non-experts and members with higher power and status naturally hold when non-experts have higher power and status than other members, but there is an exception. When organizational conditions are least favorable to speaking up on and taking action against potential problems, members with peers in terms of power and status impede the development of a common understanding. Rather than a common understanding, interactions among members lead to majority choices of action or inaction, in other words, agreements only among peers. Under this condition, members limit their spheres of communication due to the fear of being negatively sanctioned; thus, they only discuss potential problems with their peers. As a result, depending on who has peers and their opinions, majority choices of action or inaction emerge. However, under this condition, neither members' expertise nor their power and status is important. Collective-level outcomes are determined by the opinions of members who have peers in their organization regardless of their expertise and power and status.

Second, the above findings on the relationships between agents' attributes and collective-level outcomes indicate that organizational-level choices of action or inaction may depend on the opinions of those who are given the most attention but give the least attention to others. As organizational conditions become less favorable to speaking up and taking action, non-experts become the influential agents. When members attend to the power and status differences among them, the most powerful members control the organizational-level choices regardless of organizational conditions. However, when members interact only with

peers to avoid the risk of negative sanctions, the influence of the most powerful agents decreases. The purpose of Chapter 5 is to elaborate or modify these findings under expanded conditions. In the next section, I explain what factors are missing from the minimalist models and how these missing factors expand the models.

Evaluating the Effects of Feedback, Potential Embarrassment, and the Psychosocial Law

The minimalist models in this chapter are unnaturally simple so that neither spurious effects nor complexities intervene in the analyses. Although the models provide the above insights, they lack two conditions for agents' decision rules. One of these conditions is the potential embarrassment of the bystander effect, and the other is the psychosocial law of social impact theory, both of which have been mentioned in Chapter 3. The potential embarrassment changes agents' decision rule concerning when they initiate interactions, and the psychosocial law changes the rule on how they take into account and weigh counterparts' opinions.

In addition, in the minimalist models, the only feedback that agents receive concerning their decisions is new opinion values. Thus, in some cases, perpetual states of disagreement among agents emerge and, in other cases, majority choices without further convergence of opinions occur. However, not only agents in an ABS but also members in an organization are assumed to learn from their decisions. Therefore, a feedback mechanism is essential for explaining how members who are carefully selected, successfully socialized, and well adapted choose inaction against potential problems. If members are sufficiently good due to selection, socialization, and adaptation, then they are also observant and sensitive to what is occurring in their organization. Thus, they compare their choices with

those of others. If their choice is not fine-tuned to common understandings in the organization, they may change their choices in subsequent rounds of interactions.

In Chapter 5, I examine whether the insights from the models in this chapter change with the above three factors by expanding the minimalist models. For this purpose, I perform thought experiments rather than actually running the ABS. This method is selected because if thought experiments are helpful in identifying the effects of the three expanding factors, there is no need to consume extra resources for the ABS. In contrast, if new questions on the effects emerge from the thought experiments, then it is worthwhile to run the ABS. I begin the experiments by examining the effects of the feedback mechanism.

CHAPTER 5

THOUGHT EXPERIMENTS ON INFLUENTIAL AGENTS

In this chapter, I explore whether the insights from the minimalist models in Chapter 4 change by introducing feedback to agents, potential embarrassment, and the psychosocial law into the ABM. In other words, I examine which of the ABMs is worthwhile on a larger scale by making mathematical and logical deductions rather than running the ABS.

In this chapter, the following insights into organizational conditions and organizational-level choices from the minimalist models are considered. First, organizational-level choices of action or inaction depend on the opinions of those who are given the most attention but give the least attention to others. Second, as organizational conditions become less favorable to speaking up and taking action, non-experts become the influential agents. Third, however, when the agents' attribute of power and status is introduced, the most powerful agents control the organizational-level choices regardless of organizational conditions. Fourth, when agents select counterparts with the same power and status, the influence of the most powerful agents decreases.

If newly added elements of organizational conditions modify these insights or their effects are difficult to deduce without running larger models, the full-scale ABS is considered worthwhile. In contrast, if the elements do not change the insights or their effects are clear, it is not necessary to run the ABS.

Table 3 in Appendix B shows the permutations of agents' decision rules for the thought experiments in this chapter. Table 4 provides detailed explanations of each of the

rules. The first model in Table 3 is ABM 27 because ABMs 1 to 26 are the minimalist models in Chapter 4, whose details are presented in Table 1 in Appendix A. In addition, Table 3 does not have a column for "Outcomes" as in Table 1. This is because the experiments in this chapter are thought experiments. In the case of simulation runs, such as those in Chapter 4, the column is helpful in describing their outcomes one by one. In contrast, for thought experiments, explaining each outcome by enumerating them one by one is complicated and counterproductive. Thus, Table 3 describes model numbers and conditions, including agents' decision rules, but it does not describe outcomes in a simple manner.

Effects of Feedback to Agents

Feedback to Agents. In the minimalist models, no changes of opinions occur if agents become non-initiators, and agents do not reflect on their decisions and update their decision rules for subsequent rounds of interactions. In other words, agents only learn new opinions. However, as discussed in Chapter 3, it seems to be reasonable that agents' informal power and status, which is based on others' appreciation of their competency and helpfulness, fluctuates based on how their opinions align with the common understanding. It also seems to be reasonable that the fluctuations serve as positive or negative feedback, or reward, to agents. In addition, if an agent is a carefully selected, successfully socialized, and well-adapted member, as this dissertation assumes, it seems to be reasonable that a non-initiator in a round of interactions attempts to understand what others are discussing and eventually joins the interactions. Because feedback to agents involves the power and status differences among them, I first explain how agents' power and status is defined in this dissertation and then describe how their informal power and status changes due to feedback to agents.

In this dissertation, agents' formal power and status follows a power-law distribution, $PS_f = f(x) = x^{-\alpha}$, where PS_f is agents' formal power and status, x is the order of hierarchical ranks, and α is the parameter that defines how numbers of agents decrease as the ranks become higher. The power-law distribution is appropriate because the number of agents in the models does not drastically change the shape of distributions of agents' formal power and status due to its property, scale-similarity. This property is important because regardless of the total number of members, it is reasonable to assume that an organization's power and status structure has a pyramid shape to a certain degree. Between the two parameters of x and α, defining α is more difficult than defining x because α practically determines how many agents have a certain value of formal power and status.

For example, Figure 5.1 on the next page shows changes in the ratio of agents with a certain value of formal power and status when $x = 10$, $\alpha = \{1, 2, 3\}$, and $i = \{1, 2, \ldots, 100\}$, where i is an index for an agent or a member. Although the value of the parameter x is constant, the ratio of agents at a certain x decreases as the value of α increases. Thus, by controlling the parameter α, it is possible to control the degree of an organization's hierarchical structure. In the figure, the ratio of agents becomes 0.008 (i.e., practically zero) when $\{x, \alpha\} = \{5, 3\}$. Thus, only four tiers exist in the formal power and status structure in this type of organization. When $\alpha = 2$, the ratio becomes 0.01 at $x = 10$, and when $\alpha = 1$, it never becomes zero. In these organizations, nine to ten tiers exist in the formal power and status structure.

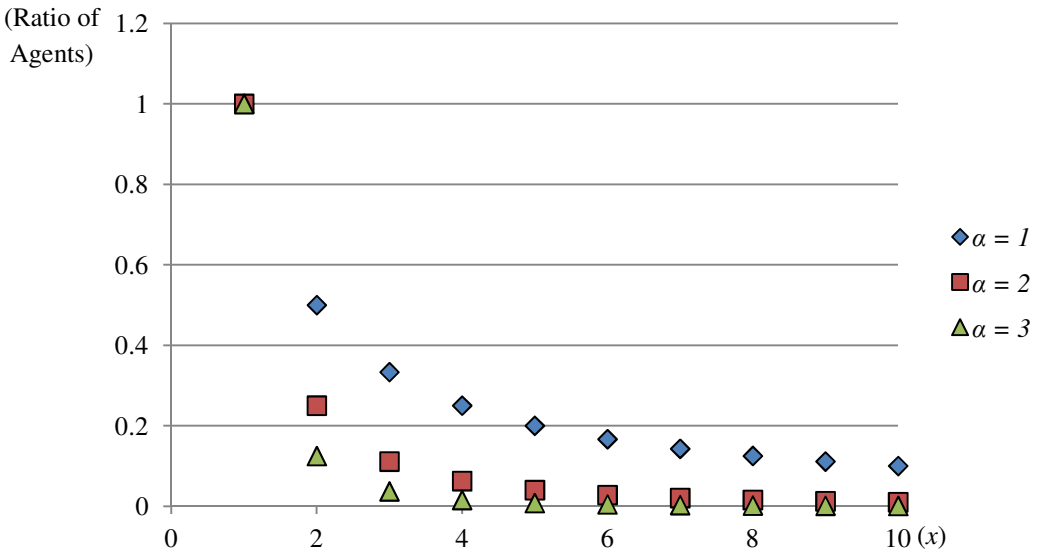

Figure 5.1. Ratio of Agents per Formal Power and Status

For informal power and status, I consider random values $PS_{inf} = \{1, 2, 3, 4, 5\}$, where PS_{inf} is agents' informal power and status. These random values are appropriate for the following reasons. First, an informal power and status structure is a product of members' impressions, which may be accurate or inaccurate, as the social psychological studies reviewed in Chapter 3 suggest. Second, it is not the interest of this dissertation to replicate and control how members develop their impressions. In addition, the values of PS_{inf} are ordinal, such as a Likert scale, assuming that the mean value of agents' impressions about an agent's competency and helpfulness changes as follows: 1 = strongly disagree that an agent is competent and helpful, 2 = disagree, 3 = neither disagree nor agree, 4 = agree, and 5 = strongly agree. Based on these definitions, each agent is given its value of power and status as $PS_i = PS_{fi} * PS_{infi}$, where PS_{fi} is an agent's formal power and status and PS_{infi} is an agent's informal power and status.

Then, how and to what extent does agents' informal power and status change because of their choices in a round of interactions? As discussed in Chapter 3, informal power and status increases if the distance between an agent's opinion and the mean of all agents'

opinions decreases after a round of interactions, whereas informal power and status decreases if the distance increases. In other words, the distance determines a new value of the informal power and status.

The value is determined by $PS_{infi@t+1} = PS_{infi@t} + \log_{100}(1/|O_{i@t+1} - \overline{O_{t+1}}|)$, where the subscript *t*+1 represents values after a round of interactions, *t* represents those before the interactions, and $1 \leq PS_{infi} \leq 5$. With this equation, the value of agents' informal power and status increases or decreases depending on the distance between their new opinions and the mean of those opinions, but the value does not become extremely large or small. In addition, the range of the new values of the informal power and status is controlled to fall within that of the original values, $PS_{infi} = [1, 5]$. However, the new values are continuous whereas the original values are discrete.

As previously explained, feedback helps agents to learn and change behaviors based on their decisions. In models in this dissertation, agents learn and change their behaviors by receiving two types of information. First, they learn from the distance between their opinions and the new common understanding in their organization, that is, the mean of the new opinion distribution after a round of interactions. If the distance decreases or remains the same, this outcome is a positive feedback to agents' choices and reinforces their decisions regarding initiating interactions. For example, if agents are experts and initiate interactions in a round, they repeat this action in the next round of interactions because of the positive feedback. If agents are non-experts and do not initiate interactions, they will maintain this behavior because of the reinforcing outcomes of their choices. If the distance increases, agents learn that their choices are poor; thus, they initiate interactions in the next round regardless of their match of expertise and opinion on what to do against potential problems.

Second, agents will be positively rewarded or negatively sanctioned with increased or decreased values of informal power and status depending on the distance, with the equation $PS_{infi@t+1} = PS_{infi@t} + \log_{100}(1/|O_{i@t+1} - \overline{O_{t+1}}|), where\ 1 \leq PS_{infi} \leq 5$. If the distance becomes greater than 1 after a round of interactions, the agents' informal power and status will decrease as the distance increases. If the distance becomes less than 1, the agents' informal power and status will increase as the distance decreases. The value 1 serves as the threshold in terms of the increase and decrease because it is theoretically the largest distance between agents' opinions and the mean of original opinion distributions in the ABMs of this chapter. These changes in the informal power and status change individual agents' power and status and the entire power and status structure in the organization. The new power and status structure determines how agents choose their counterparts and weigh the opinions of the counterparts in the next round of interactions.

The feedback mechanism may intervene in the relationship between organizational conditions and organizational-level choices and, thus, change the insights from the minimalist models in Chapter 4. However, the intervention occurs in a random world rather than a symmetric world, as explained below.

Symmetric versus Random World. In a symmetric world, initial distributions of agents' attributes are balanced. For example, agents' opinions have a perfect uniform distribution of $O \sim U(-1, 1)$. Their match of expertise has a perfect binomial distribution, $B(1, \beta)$, with which agents are assigned a value for this attribute from the Bernoulli trial; 1 = match of expertise to the field of potential problems and 0 = no match. In this type of world, the feedback mechanism is not important because agents' opinions are destined to converge toward the mean of the initial distribution once those agents become initiators.

For example, assume that agents initiate interactions if they are experts (ABM 27 in Table 3 in Appendix B). The number of initiators is determined by the binomial distribution of agents' match of expertise, especially the parameter value of β, which defines the probability that agents have expertise that matches the field. If the value is less than 0.5, experts, and thus initiators, become the minority in rounds of interactions. If the value is greater than 0.5, the experts and initiators become the majority. The experts interact with each other and change their opinions. In this symmetric world, the parameter value is 0.5 and there are equal numbers of experts and non-experts in an organization. Therefore, half of the agents become initiators but the other half never joins discussions and never changes their opinions, regardless of whether those opinions are pro-action, which is close to 1, or anti-action, which is close to -1. Through rounds of interactions, initiators determine their opinions by calculating the weighted means of all agents' opinions depending on the counterparts' expertise (Change Rule 0B in Table 4). Regardless of the feedback mechanism, organizations in this world never reach an agreement; rather, they fall into a perpetual state of disagreement for the following reasons.

First, initiators' opinions after the first round of interactions become 0.0, the mean of the perfect uniform distribution. The new opinion values do not change regardless of how many rounds they repeat interactions. Second, non-experts, and thus non-initiators, receive positive feedback on their inaction because the distance between their opinions and the new mean remains the same as that before interactions among experts/initiators. As a result, the non-experts remain non-initiators and their opinions remain the same regardless of interactions among experts. These outcomes do not change even if the parameter value of β decreases or increases, switching experts between the majority and the minority. The lack of

changes in outcomes in spite of changes in the parameter value has an interesting theoretical implication. The parameter represents the degree to which an organization is specialized; as the value decreases, the degree of organizational specialization increases. As explained in Chapter 3, the third group of social psychological studies implies that high degrees of specialization may lead to organizational inaction. However, no significant differences are expected across different values of the parameter β. Thus, in contrast to the argument of the third group of social psychological studies, it is likely that the causes of organizational inaction are not specialization.

The above outcomes are the same as the outcome in Figure 4.4, for which the ABM has no feedback mechanism. In the figure, experts' opinions become 0.25 after interactions and the value is the simple mean of non-experts' opinions. In the case of the symmetric world above, the new mean of experts' opinions, 0.0, is equal to the simple mean of non-experts' opinions, which uniformly distribute between -1 and 1. In other words, the feedback mechanism does not impact organizational-level choices.

However, a real world, i.e., a random world, is not symmetric. For example, there is not always an even number of members in an organization. Distributions of experts and members' opinions are biased. In this random world, slight changes, or biases, in the distributions may allow the feedback mechanism to impact organizational-level choices and the choices may sway between an action against potential problems and inaction against those problems.

For example, if an agent whose opinion is larger than 0.0 is added, then the mean of the initial distribution of agents' opinions becomes greater than 0.0. The distance between the original opinions and the mean decreases if the opinions are greater than 0.0 but increases if

the opinions are less than 0.0. With Initiating Rule 2, only experts become initiators and they calculate the weighted mean of all agents' opinions, following Change Rule 0B (as in ABM 28 in Table 3). In this case, the initiators' opinions move closer toward 0.0 in the first round of interactions. This change also pushes the mean of the new opinion distribution downward toward 0.0. As a result, the experts/initiators receive positive feedback on their choices and continue to initiate discussions in the next round of interactions. For non-experts whose original opinion values are less than 0.0, however, this downward shift of the mean generates positive feedback on their inaction because the distance between their opinion and the mean decreases from that prior to interactions among experts/initiators. Thus, their behaviors do not change; they do not join the interactions in the next round and their opinions do not change. In contrast, non-experts whose original opinion values are greater than 0.0 receive negative feedback from the change in the mean, or the common understanding in the organization. Due to the feedback, they join the next round of interactions.

The downward shift of the mean and patterns of feedback above continue until organizational-level choices eventually converge to the extreme opinion that favors inaction, that is, -1.0. Although non-experts with opinion values less than 0.0 remain non-initiators across rounds of interactions, interactions among initiators continue to push the mean downward so that it eventually becomes lesser than their opinion values and the distance between the mean and the opinions becomes greater than that before a round of interactions. Therefore, the non-experts eventually join discussions and their opinions continue to move toward -1.0. In other words, by adding only one expert whose opinion value is greater than the mean of the initial opinion distribution, organizational-level choices become a consensus

of inaction from a perpetual state of disagreement among agents due to the feedback mechanism.

If the added agent is a non-expert, organizational-level choices eventually become a consensus to take action against potential problems; in other words, non-experts' opinions of 1.0 determine the choices. The mechanism behind this change is the same as above but works in the opposite direction. If the agent is a non-expert, its inaction moves the mean following interactions upward. Because of the upward shift, non-experts whose opinions are less than 0.0 eventually become initiators, excluding those with extreme opinions that favor action, 1.0. If the opinions of the added agent are less than 0.0 and if the agent is an expert, and thus an initiator, the addition generates a pressure to push the mean upward, the upward shift of the mean generates negative feedback to non-experts whose opinions are less than 0.0, and the non-experts eventually join the discussions. In this case, organizational-level choices become a consensus to take action against potential problems. If the agent is a non-expert, the mean begins to move downward by its addition and organizational-level choices become a consensus of inaction against the problems.

The above changes have three implications for the insights from the minimalist models in Chapter 4. First, a slight imbalance in initial conditions causes organizational-level choices to switch between action and inaction against potential problems. Second, the feedback mechanism does not change the basic insight from the minimalist models but adds a new insight. The basic insight is that the opinions of those who are given the most attention but give the least attention to others determine organizational-level choices. In the models, these members are non-experts. The new insight is that they are non-experts whose original opinions are the most extreme and distant from the original common understandings in the

organization. In addition, organizational-level choices become the opposite extreme of the opinions of agents who are sources of the imbalance if those agents are experts/initiators. In contrast, the choices reach the same extreme end of opinions if agents are non-experts even though these non-experts are sources of the imbalance. Finally, these differences in organizational-level choices modify the implication on the relationship between specialization and organizational inaction from the thought experiment on the symmetric world. In the symmetric world, degrees of specialization do not impact organizational-level choices of action or inaction. However, in the random world, the degrees of specialization may impact the extent to which those degrees determine who will become the source of imbalance. If an organization is highly specialized, it has more experts as the source of imbalance. If an organization is not highly specialized, it has a larger population of non-experts as the source. Thus far, the outcomes of the thought experiments on the random world suggest that the opinions of the sources of imbalance may determine organizational-level choices.

Power and Status Introduced. In the above thought experiments, the feedback mechanism simply concerns the distance between individual agents' opinions and the mean of distributions of all opinions. However, the feedback mechanism also indicates that agents' informal power and status fluctuates due to positive or negative sanction depending on the distance. In the minimalist models in Chapter 4, the opinions of agents with higher power and status determine collective-level choices regardless of their match of expertise once the attribute of their power and status is introduced into the models. With the feedback mechanism, the insights into the relationships between who is the most powerful and who is given the most attention may change based on how agents select their counterparts.

For example, assume that initiators choose any other agents as their counterparts, following Search Rule 1 (as in ABM 29 in Table 3). By interacting with those counterparts, the initiators calculate the weighted means of their opinions based on the counterparts' match of expertise and power and status (Change Rule 0D in Table 4). Under this condition, organizational-level choices do not differ from those in the above models in a random world.

First, an added agent and its opinion value, in other words, a source of an imbalance, set the general trend of upward or downward shift of the mean of agents' opinions. Then, initiators interact with any other agents and weigh experts' opinions and the opinions of powerful agents as twice the amount of others' opinions. If a counterpart has the same power and status, its opinion is weighed as 1. If the counterpart's power and status is lower, its opinion is weighed as half of its value. Because this aspect of the change rule concerning agents' power and status applies to all agents regardless of expertise, differences in power and status can be disregarded in the discussion of the influences of non-experts' opinions. Although the rate of changes in the common understanding, or the slope of changes in agents' opinions, may vary depending on the power and status difference and changes in this difference due to feedback on their informal power and status, non-experts with the most extreme opinions favoring action or inaction eventually attract all other agents' opinions. Even if the power and status of a non-expert is lower than that of other non-experts, the lower power and status is not important if the agent's opinion is more extreme than the opinions of other non-experts. Thus, under the condition that initiators interact with others regardless of their power and status, following Search Rule 1, the insights into non-experts and the effect of the feedback mechanism hold well. Agents' power and status does not impact

organizational-level choices, which differs from the insights in Chapter 4 on the relationship between the agents' attribute of power and status and organizational-level choices.

Then, what occurs if agents become more selective in choosing their counterparts? If they only choose counterparts with higher power and status than their own (Search Rule 3, as in ABM 30), organizational-level choices differ from the above. The basic insight that agents' power and status determines their influence becomes effective in some cases but not in other cases. Under this condition, it is difficult to predict how individual agents' opinions change because the changes depend on agents' power and status, with which initiators calculate weighted means of their opinions based on the counterparts' match of expertise and power and status (Change Rule 0D). However, it is possible to predict how non-experts continue to attract other agents' opinions.

First, the distance between non-experts' opinions and the mean of all agents' opinions decreases. While the distance decreases, non-experts' power and status continues to increase because of the feedback mechanism; thus, weight of their opinions increases when initiators change their opinions. The non-experts also remain non-initiators. In addition, if the power and status of the non-experts is higher than other agents' power and status at the beginning and their informal power and status quickly reaches the maximum value of 5, then their power and status becomes the highest among all of agents. As a result, they do not have opportunities to become initiators or to have counterparts to change their opinions. In this case, the opinions of these non-experts determine organizational-level choices.

Second, even if the distance increases and non-experts become initiators, they do not have counterparts to change their opinions if their power and status is higher than other agents' power and status. For example, a non-expert with the highest power and status from

the beginning never changes its opinion even if it becomes an initiator in a round of interactions. In this case, the opinions of these non-experts attract other agents' opinions and determine organizational-level choices, which is the same as the above case.

However, the same effect of agents' power and status appears even if they are experts. Because experts initiate interactions and continue to change their opinions so that their opinions come closer to the mean, they tend to continue to receive positive rewards for their choices. Depending on the initial values of their power and status, some of the experts reach higher power and status more quickly than any other agents. Then, they have no counterparts to change their opinions and their opinions are given the greatest weight by other initiators, including non-experts. In this case, experts' opinions determine organizational-level choices. In other words, as members become more selective in terms of their counterparts, agents' match of expertise is unimportant and their power and status determines organizational-level choices. The most powerful members become those who are given the most attention and give the least attention to others regardless of their expertise, which replicates the insight from the minimalist models in Chapter 4.

With the above effect of agents' power and status and the feedback mechanism, the organizational-level choices are not always extreme choices that favor action or inaction. In addition, due to the effects of agents' power and status and the feedback mechanism, the choices are not always a consensus. In this case, the insight must be modified.

For example, assume that changes in agents' opinions are producing a downward push of the mean of those opinions. In the same organization, some non-experts have an extreme opinion that favors inaction, that is, -1.0. Under this condition, these non-experts do not become initiators and their opinions are not affected by changes in other agents' opinions

regardless of their power and status, whereas their opinions attract other initiators' opinions. Then, assume that one of the experts has a less extreme opinion that favors inaction and the highest value of power and status from the beginning. Even if the expert becomes an initiator, the agent has no counterpart and its opinion remains the same. However, because the mean of agents' opinions continues to come closer to the expert's opinion, the expert's informal power and status continues to rise to its maximum value, 5, and the expert's power and status, which is the product of its formal and informal power and status, also reaches its highest possible value.

In this process, the agent's opinion continues to attract other initiators because initiators calculate the weighted means of their opinions based on the counterparts' match of expertise and power and status (Change Rule 0D), and the informal power and status of these attracted initiators also continues to increase. If the attracted initiators also have higher power and status than other agents from the beginning, their counterparts eventually become limited to the most powerful expert. As a result, the opinions of this expert and the attracted initiators converge. Other initiators, regardless of their expertise, choose the above non-experts, expert, and attracted initiators as counterparts based on their power and status and accordingly change their opinions. If their power and status is lower than the other initiators' power and status, they have more counterparts and their opinions near -1.0. If their power and status is higher, they have fewer counterparts and their opinions near the less extreme opinion. However, all of those initiators' opinions distribute between the less extreme opinion and -1.0.

Without agents' power and status and the feedback based on changes in power and status, the opinions eventually converge to -1.0, as occurred in the first experiment of this

section. However, this convergence does not occur if the most powerful expert attains the possible highest value of power and status in earlier rounds of interactions than rounds in which non-experts with the most extreme opinions and other comparatively powerful initiators attain the possible highest value of their power and status. If the timing is earlier, the expert's opinion value ceases to change and begins to attract the other comparatively powerful initiators' opinions, as explained above. However, at the same time, it begins to block the mean of agents' opinions so that the expert's opinion value does not become smaller than itself. As a result, agents' opinions are eventually fixed between the less extreme opinion and -1.0 and they do not convergence. The outcome is a perpetual state of disagreement or, at least, a lack of consensus on what to do against potential problems.

In short, under this condition, organizational-level outcomes depend on both non-experts' opinions regardless of those agents' power and status and the opinions of the most powerful experts. This outcome of the thought experiment on the feedback mechanism above modifies the insights into the relationship between the agents' attribute of power and status and organizational-level choices; the most powerful agents do not always determine the choices. The problem here is that it is difficult to predict how quickly the expert attains its possible highest power and status and how probable such attainment is without running the ABS.

If agents select counterparts with the same or higher power and status (Search Rule 2, as in ABM 31), the outcomes of a thought experiment are the same as those of the above experiments in which agents select counterparts with higher power and status (Search Rule 3). With Search Rule 2, the number of counterparts is greater than that with Search Rule 3. However, because of Change Rule 0D (i.e., initiators weigh counterparts' opinions based on

their power and status in addition to match of expertise), differences in opinions after a round of interactions result from differences in power and status. In other words, only the opinions of counterparts with higher power and status have an impact. Thus, the outcome is the same as when agents only interact with counterparts with higher power and status. This reasoning is also compatible with the outcome when the attribute is introduced into the minimalist models in Chapter 4. In the section "'Power and Status' and Changes in the Search Rule and Change Rule", the mechanism behind organizational-level choices is the same in the condition with Search Rule 2 and that with Search Rule 3. The major difference in the mechanism occurs when the agents' decision rule is changed so that agents only select counterparts with the same power and status (Search Rule 4). I explain what occurs under the condition with the feedback mechanism below.

When agents select counterparts with the same power and status only (Search Rule 4, as in ABM 32), organizational-level choices are not determined by agents' match of expertise or the extremeness of their opinions. Rather, their power and status takes control as follows. First, because of the combination of Search Rule 4 and Change Rule 0D, initiators change their opinions by calculating the arithmetic mean of counterparts with the same power and status. Although Change Rule 0D dictates that agents weigh the opinions of counterparts based on differences in their power and status, only agents with the same power and status become the counterparts. Those counterparts' opinions are weighed as 1; thus, the calculation of the weighted means of their opinions is equal to the calculation of the simple means. In short, agents' interactions lead to clusters of different opinions among interactants with the same power and status, and those opinions are the simple mean of different groups of the interactants' opinions. Second, because of the search rule, even if agents become initiators

regardless of their match of expertise, they do not have counterparts unless other agents have the same power and status. These initiators' opinions remain the same across rounds of interactions, and these unchanged opinions form other clusters of opinions.

Third, if the distance between agents' opinions and the mean of those opinions continues to decrease, these agents continue to receive positive feedback and their informal power and status continues to rise. Otherwise, their informal power and status continues to fall. This feedback mechanism may result in two changes. Initiators without counterparts eventually have some counterparts and their opinions begin to change. In addition, after all agents' informal power and status reaches the maximum value, differences in agents' power and status become nearly proportional to their formal power and status. This is because the values of agents' power and status are equal to their formal power and status, which follows a power-law distribution, multiplied by their informal power and status, which is randomly generated between 1 and 5 and fluctuates in the same range due to the feedback mechanism. I have said "nearly" because the following conditions may intervene in agents' power and status before values of the attribute reach the equilibrium: when agents become initiators and join interactions and whether they have counterparts. In other words, clusters of different opinions may change or even converge to a certain degree, but agents eventually limit their counterparts because they interact only with those with the same power and status (Search Rule 4) and because the feedback mechanism is working. As a result, clusters of opinions do not completely dissolve.

The above three effects of Search Rule 4 suggest that organizational-level outcomes under the condition likely become a perpetual state of disagreement in which agents' opinions split into clusters. How many clusters are formed, which agents' opinions do or do

not change, and to what extent those clusters converge or disperse depend on agents' power and status. In the process, agents' match of expertise or extremeness of their opinions is unimportant. In contrast, the following three conditions determine the outcomes: number of agents that share the same values of power and status, the speed with which their opinions near the mean of new opinion distributions, and the speed with which their informal power and status reaches the maximum value, 5, in a series of interactions. The first of the three conditions partly depends on values of the parameter α in $PS_f = f(x) = x^{-\alpha}$. Figure 5.1 shows that as values of α increase, the number of agents with lower formal power and status and the number of agents that share the same formal power and status increase. The actual values of agents' power and status differ from these distributions due to the effects of their informal power and status. However, the feedback mechanism eventually revives those distributions of agents' power and status, and Search Rule 4 prevents agents' opinions from changing beyond the restriction of the distributions.

The above effects of the feedback mechanism combined with Search Rule 4 are a complicated version of the findings in Chapter 4. In Chapter 4, this search rule changes members who are given the most attention from agents with higher power and status to those with the same power and status. In addition, their match of expertise is unimportant. These outcomes also occur in the above paragraphs. In addition, the search rule excludes some agents from interactions because their power and status is higher or lower than other agents' power and status; this exclusion leads to a lack of consensus among the agents. This outcome also occurs above. In Chapter 4, organizational-level outcomes become a majority choice of action or no changes from initial opinions because the ABMs in the chapter are the minimalist models, the number of agents is only three, and the values of their attributes are

fixed. In contrast, under more randomized conditions, organizational-level outcomes are clusters of different opinions with some fixed opinion values because initial opinion distributions are more random. However, the mechanism that leads to the outcomes is the same. When organizational conditions are least favorable to speaking up and taking action, the agents with the greatest number of peers are those who are more likely to be given attention. A caveat is that these agents are not necessarily those who are given the most attention and give the least attention to others; thus, their opinions are not sufficiently deterministic to result in a consensus on what to do against potential problems. However, again, this result is the same as that in the minimalist models in Chapter 4.

In short, for Search Rule 4, the simple, minimal models are sufficient for studying the relationships between organizational conditions and organizational-level outcomes and, thus, a large-scale ABS is unnecessary. The above thought experiments clarify the insights of Chapter 4, in which the outcomes with Search Rule 4 seem to be exceptions whose mechanism is difficult to sufficiently explain.

Summary of the Effects of the Feedback Mechanism. The above thought experiments clarify three points on how the feedback mechanism in the ABMs may change behaviors of the ABS and, thus, clarify the insights of the minimalist models in Chapter 4.

First, when agents select any other agents as their counterparts (Search Rule 1) and receive feedback on their new opinions, non-experts with opinions that most extremely favor action or inaction are those who are given the most attention but give the least attention to others. This is a new insight on the influence of non-experts in determining organizational-level choices. In addition, if agents are not selective in choosing their counterparts, power and status differences among agents do not impact the non-experts' influence and

organizational-level outcomes in spite of changes in one of their decision rules, the change rule. This is also a new insight.

Second, when agents become more selective in terms of their counterparts, organizational-level choices become either a consensus or a lack of consensus, and the effects of the feedback mechanism and agents' search rules differ between the two cases of outcomes. In the above thought experiments, agents select their counterparts with the same or higher power and status (Search Rule 2) or select those counterparts with higher power and status only (Search Rule 3). If the most powerful agents are those who are given the most attention but give the least attention to others, those agents' opinions determine organizational-level choices and the choices are a consensus of either action against potential problems or inaction depending on the opinions. In this case, agents' match of expertise is irrelevant to who becomes influential. The influence of the most powerful agents and irrelevance of agents' expertise have been described in the insights of the minimalist models and, thus, are not new. However, when organizational-level outcomes are the lack of consensus, the state of disagreement emerges from two sources: opinions of the most powerful experts and the most extreme opinions of non-experts regardless of their power and status. In other words, the two different effects work together when members do not reach an agreement concerning potential problems, and this differs from the insights of the minimalist models.

Third, when agents become further selective and begin to choose only those with the same power and status as their counterparts (Search Rule 4), agents' power and status determines organizational-level outcomes. The outcomes are a perpetual state of disagreement and agents' expertise is irrelevant in the process. However, not the most

powerful agents, but the agents with the greatest number of peers become those who are given the most attention. The opinions of those agents lead organizational-level choices to a lack of consensus because power and status differences cause different opinions to cluster by interactions among initiators with the same power and status. In other words, those who are given the most attention cannot be those who are most influential. They are also not those who give the least attention to others. In a sense, this mechanism aligns with the insights of the minimalist models; without members who are sufficiently influential to guide others' opinions to an agreement, an organization is not able to make a decision and organize its members for a coordinated action against potential problems. For this purpose, an organization needs a member who is given the most attention but gives the least attention to others.

Then, which is a worthwhile model for large-scale runs of the ABS to advance the insights into how organizational-level choices emerge from members' interactions? One reason to run the ABS is that it is helpful in verifying the above deductions and insights. For example, in the thought experiments in this section, it is not clear how quickly experts attain the highest possible values of their informal power and status and how probable such attainment is because of the feedback mechanism. The question on the probability seems to be trivial for exploring and explaining the mechanisms behind organizational inaction; however, when considering how rare but salient events occur because of organizational inaction against potential problems, this probability is important. For example, the feedback mechanism is not effective in the symmetric world without randomness, but it impacts organizational-level choices in a random world. In the world, agents' opinions change under the influence of non-experts whose opinions favor action or inaction receiving feedback on

their choices. In other words, if members successfully learn from other members when their organization is in a "gray zone", their interactions and consequent learning may help an organization and the public to avoid rare but salient events. An advantage of the ABS is the ability to introduce this randomness into the symmetric world in the form of experiments and provide data on the probabilities that such a change occurs. In contrast, it is possible to explain mechanisms behind organizational-level choices and, thus, relationships between members' interactions and those choices without running the ABS. In this regard, no further simulation with larger models is necessary concerning the effects of the feedback mechanism.

In the next section, I discuss the effects of potential embarrassment, which is based on the inferences from theories on the bystander effect, as reviewed in Chapter 3. Because of potential embarrassment, one of the agents' decision rules, the initiating rule, changes. Then, I proceed to discuss the effects of the psychosocial law from social impact theory. Introducing the law changes agents' decision rules concerning how they weigh counterparts' opinions, that is, the change rule. Because the effects of the feedback mechanism are fully explained in this section, the mechanism is disregarded in the thought experiments in the following sections.

Effects of Potential Embarrassment

What is Potential Embarrassment? One of the factors of the bystander effect, as explained in Chapter 3, is potential embarrassment. According to Latané and Nida (1981), bystanders fear embarrassing themselves and others by taking action when other bystanders are not acting even though an individual is in need of aid. They worry that their perception of a problem may be inaccurate because no one takes action. This factor of the bystander effect implies that even if a member perceives a problem in an organization, s/he checks whether

others share his/her perception on potential problems at the beginning, and the seemingly shared perception determines whether s/he initiates action.

Thus, in an environment in which speaking up and taking action are not welcomed, an agent's initiating rule becomes stricter than that in prior sections, i.e., agents initiate interactions if they have appropriate expertise and a certain percentage of other agents share the perception of potential problems. To learn others' perceptions before initiating serious interactions, agents must first contact a limited number of others. These others are comparable to a limited circle of confidants. In addition, their perceptions are comparable to a common understanding at the collective level (not the organizational level) in the eyes of an agent, which may differ from one collective to another in an organization.

To study the effects of potential embarrassment, it is necessary to define the following two factors: the number of confidants that an agent questions and the percentage of the confidants that share the agent's perception. If an agent performs an end-to-end search in its environment of the ABS in this dissertation, the distance is $\sqrt{(50^2 + 50^2)} \approx 71$, which has been used in other models in this chapter. However, concerning the confidants, such a search is overly burdensome. In addition, studies on the core discussion network, which is a limited circle of people who discuss sensitive issues, suggest that the number of confidants is less than three (Hampton, Sessions and Her 2011; Marsden 1987; McPherson, Smith-Lovin and Brashears 2006). Thus, in this dissertation, an agent performs the preliminary inquiries by questioning the first three agents that it encounters in its environment. Then, I compare organizational-level outcomes in the following three cases: an agent initiates full-scale interactions if only one of the three confidants has opinion values equal to or greater than its own, two of the confidants have such values, or all of them have such values. The conditions

to initiate interactions become stricter as the number of confidants who have opinion values equal to or greater than an inquirer's opinion increases.

From the above description on the potential embarrassment, one effect has become predictable. Because the embarrassment tends to hamper agents from initiating interactions, the number of initiators should decrease as the condition regarding confidants becomes stricter. However, the current question is how the reduced number of initiators changes (or does not change) collective choices at the organizational level. As in the last section, I examine the effects both in the symmetric and random world.

Potential Embarrassment in the Symmetric World. The initial conditions in the symmetric world are the same as those in the last section. Agents' opinions distribute in a perfectly uniform form, $O \sim U(-1, 1)$, and their match of expertise is a perfect binomial distribution, $B(1, 0.5)$. To focus on the effects of potential embarrassment, no feedback mechanism is introduced to the thought experiments in this section. Agents question three confidants if their expertise matches the field of potential problems and they initiate full-scale interactions if the confidants have opinion values equal to or greater than their own. If only one confidant satisfies the condition, this represents Initiating Rule 3A. If two confidants satisfy the condition, this represents Initiating Rule 3B. The strictest rule is Initiating Rule 3C, in which all three confidants satisfy the condition.

In this symmetric world, organizational-level choices are the same as those in the symmetric world in the previous section, that is, they quickly converge toward the mean of agents' original opinions, 0.0, and remain there regardless of rounds of interactions. This prediction is sound for a few reasons.

First, due to the symmetric distribution of agents' match of expertise, half of them question their confidants. In contrast, the other half does not initiate interactions; thus, their opinions do not change and the mean of their opinions remains at 0.0. Second, among the experts who make the inquiries, only those with at least one confidant whose opinion is equal to or greater than their own initiate interactions, following Initiating Rule 3A (e.g., ABM 33 in Table 3). However, because of the symmetric opinion distribution, $O \sim U(-1, 1)$, all agents in this model may have at least one confidant who satisfies the condition. As a result, it is safe to assume that all of the experts become initiators and begin full-scale interactions. Due to the interactions, the experts' opinions become 0.0 because agents calculate the weighted means of all opinions depending on their expertise, following Change Rule 0B. This outcome of full-scale interactions reinforces the mean opinion value among non-experts. Third, even if some experts have more than one confidant and continue interactions, the interactions do not impact the organizational-level choice because their opinions have been at the mean of their original opinions, that is, 0.0. In other words, regardless of the number of the confidants, the organizational-level outcome never changes.

The outcome and effects of potential embarrassment in general do not change even if more confidants become necessary as the initiating rule changes into 3B and 3C in ABMs 34 and 35. Stricter conditions on the confidants reduce the number of initiators who begin full-scale interactions and not all experts become initiators. However, the mechanism that results in organizational-level choices is the same as that in the above paragraph, in which agents initiate interactions if at least one confidant has an opinion equal to or greater than its own. The choices always fall into the mean of original opinion distributions. With these thought experiments, it is clear that potential embarrassment in the symmetric world does not change

organizational-level choices from those in the minimalist models in Chapter 4. Experts' opinions move toward 0.0, which is the mean of all agents' opinions including non-experts, regardless of the degree of potential embarrassment. Then, what occurs in the random world?

Potential Embarrassment in the Random World. In the previous section concerning the effects of the feedback mechanism, adding one expert or non-expert changes organizational-level choices. Potential embarrassment is assumed to have the similar tipping effect in the random world, but the outcome depends on a few conditions. First, it depends on whether the added agent is an expert or a non-expert. If the agent is an expert, it is more likely to initiate full-scale interactions; thus, its opinion may have less influence on organizational-level choices than that of non-experts. Second, it depends on whether the expert has a sufficient number of confidants to initiate full-scale interactions. If it has such confidants, the original opinion of non-experts will have a larger effect on organizational-level choices than otherwise. For example, consider a case in which an added agent is a non-expert. If the non-expert has an extremely pro-action opinion whose value is 1.0, organizational-level choices will also become pro-action compared to those in the symmetric world, in other words, greater than 0.0, because of the following mechanism.

On the one hand, the non-expert neither questions his/her confidants' opinions nor initiates full-scale interactions due to his/her lack of expertise. Therefore, his/her opinion does not change. On the other hand, experts become initiators of full-scale interactions if they have a sufficient number of confidants who satisfy the conditions of the initiating rule (e.g., ABMs 36 to 38 in Table 3). Those who become the initiators search for the opinions of all other agents. Then, they calculate the weighted mean of those opinions plus their opinion, following Change Rule 0B. As a result, due to the pro-action opinion of the non-expert, the

initiators' opinions and choices at the organizational level become more prone to action against potential problems (i.e., with values that are greater than 0.0) than those in the symmetric world. If the newly added non-expert has an opinion that extremely favors inaction, i.e., -1.0, the same mechanism will move individual- and organizational-level choices to inaction.

In the case that a new member is an expert, the same mechanism also determines which agents initiate full-scale interactions and whose opinions are influential. However, in this case, the potential embarrassment may impact the degree to which organizational-level choices become pro-action or pro-inaction. If the added expert's confidants satisfy the conditions of the initiating rule and s/he initiates full-scale interactions, the expert calculates the weighted mean of all agents' opinions, following Change Rule 0B. In addition, other experts weigh the added expert's opinion in the same manner. In the process, if the expert's opinion is pro-action, interactions among agents may cause organizational-level choices to shift toward pro-action compared to those in the symmetric world. If the opinion is anti-action, the choices may shift toward more anti-action than those in the symmetric world. Concerning these shifts, it is noteworthy that organizational-level opinions tend to move in an opposite direction from the expert's opinion while all experts' opinions in general move toward the mean of all agents' opinions.

If the added expert does not have a sufficient number of confidants to initiate interactions, the degree of the shifts will increase due to the expert's opinion. In such a case, the opinion of the expert does not change, whereas other experts calculate the weighted mean of the opinions of all agents, including the added expert who does not initiate interactions. As a result, compared to the case in which the expert initiates full-scale interactions, his/her

opinion contributes more to shift other agents' opinions toward itself if the expert does not initiate full-scale interactions. In other words, the impact of the expert's opinion on organizational-level choices tends to be larger if s/he does not initiate interactions than if s/he initiates interactions.

Thus far, the thought experiments have clarified how potential embarrassment modifies the findings of the minimalist models in Chapter 4. In the minimalist models, the opinions of those who are given the most attention and who give the least attention to others determine organizational-level choices. These members are non-experts unless members' power and status is considered. In the experiments in this section, the lack of expertise is not as important as in the minimalist models. The important factors include how easily individual members succumb to the effect of potential embarrassment even if members are experts. As agents become more vulnerable to potential embarrassment, that is, as the initiating rule becomes stricter with the increasing number of confidants sufficient to initiate interactions, fewer agents initiate full-scale interactions. It is less likely that members initiate full-scale interactions under the condition that they need more support or acceptance from surrounding individuals to break silence even if they have expertise that matches the field of potential problems. This timidity of experts paradoxically increases their influence on organizational-level choices because experts who initiate organization-wide discussions consider the opinions of the timid experts and others' opinions. In short, under the condition that the potential embarrassment is introduced, those who are given the most attention and who give the least attention to others may be either experts or non-experts, but they are members who do not speak up about their concerns beyond small circles of confidants.

Although the above findings are counterintuitive, they conform to existing theories on the bystander effect. According to the theories, observers become bystanders because they imitate the surrounding inactive people's behavior – observing rather than helping an individual in need of aid. A factor of the effect, lack of expertise, hampers observers from taking initiative. Another factor, the potential embarrassment, also deters the observers. The mutual deterrence among observers reinforces the influence of those who do not act. In other words, the opinions of inactive people are most powerful in determining the choice of a collective of people. In the next section, I examine the effect of introducing power and status into agents' decision-making.

Power and Status Introduced. Introducing power and status alters agents' search rule that determines with whom they interact. It has become clear in Chapter 4 and in the first section of this chapter that agents' opinions shift toward those held by agents with higher power and status when they select counterparts with the same or higher power and status, following Search Rule 2, or when they select counterparts with higher power and status, following Search Rule 3. In contrast, when agents select only counterparts with the same power and status by following Search Rule 4, agents with more peers become influential in determining organizational-level choices. Considering the same outcome with Search Rules 2 and 3, I study the outcome when agents follow Search Rules 3 and 4 to examine the relationship between the potential embarrassment and agents' power and status. Because the new attribute of agents – power and status – is introduced, initiators calculate the weighted mean of agents' opinions based on these agents' match of expertise and power and status, following Change Rule 0D. Agents follow the same initiating rules as those previously presented in this section. Table 3 shows the combinations of these rules.

When agents select only counterparts with higher power and status, that is, when they follow Search Rule 3 (as in ABMs 39 to 41 in Table 3), the power and status of a newly added agent and its vulnerability to potential embarrassment are important. Even if the agent is an expert, as the initiating rules become stricter and demand that more confidants satisfy the conditions of the rules, the probability that the agent initiates full-scale interactions decreases. If the agent does not become the initiator, its opinion is more influential in determining organizational-level choices than otherwise because other initiators take into account its opinion, whereas the opinion does not change. If the opinion is pro-action, organizational-level choices will shift toward action compared to those in the symmetric world. If it is anti-action, the choices will shift toward inaction. In addition, the opinion's influence depends on the agent's power and status. As the power and status increases, it is more likely that the opinion is determining organizational-level choices because other initiators weigh the opinion more than other opinions. In short, under this condition, members who do not initiate full-scale interactions and have higher power and status become more influential than other members.

If agents select counterparts with the same power and status, that is, when they follow Search Rule 4 (as in ABMs 42 to 44), the influence of the opinion of a newly added agent depends on the number of the agent's peers. As the number of the peers decreases, the influence also decreases. In other words, agents that are more powerful are replaced with those that are more common in terms of those who are given the most attention. This finding may provide insight into theories on the bystander effect. Members may become bystanders not only when a more powerful individual favors inaction but also when an individual who is similar to them favors it. In short, homophily may influence collective and organizational

inaction against potential problems. After the potential embarrassment reduces the number of initiators of full-scale interactions, homophilial tendencies among members determine who is given the most attention and gives the least attention to others.

Summary of the Effects of Potential Embarrassment. Potential embarrassment does not change organizational-level choices in the symmetric world from those in the minimalist models. In the symmetric world, the choices are the mean of all agents' original opinions regardless of potential embarrassment. In other words, the different initiating rules do not impact the organizational choices of action or inaction. In contrast, in the random world, the potential embarrassment affects organizational-level choices. In this world, those who are given the most attention but give the least attention to others, that is, members who influence the choices, are not only non-experts but also experts who succumb to the potential embarrassment. In short, members who do not initiate organization-wide discussions tend to be the most influential in determining the organization's action or inaction against potential problems.

This tendency does not change even if members select counterparts of their discussions based on power and status differences. Although power and status differences exert certain effects on organizational-level choices, the effects are constrained by how easily members succumb to potential embarrassment. Those who are given the most attention but give the least attention to others are members who are subject to potential embarrassment. Then, the power and status structure is important. If initiators discuss potential problems with those with the same and/or higher power and status, those who are higher in power and status tend to determine the organizational-level choices of action or inaction. When organizational conditions become less favorable to speaking up, in other words, in an organization in which

initiators discuss problems only with peers, those with more peers tend to determine the choices.

Effects of the Psychosocial Law

The last condition of the thought experiments is the psychosocial law. In this section, I first explain the law and then perform the experiments with three different change rules for agents' decision-making.

What is The Psychosocial Law? In the minimalist models in Chapter 4, agents change opinions by calculating simple or weighted means of opinion values in each round of interactions. However, simply calculating the mean is counterintuitive as a process of individual decision-making. In a more realistic decision-making process, the impact of others' opinions varies depending on their power, status, timing of encounters, number of counterparts, etc. For example, if a person repeatedly hears the same opinion from different people, s/he feels satiated with the opinion and its impact decreases as the person hears the opinion later. In other words, the psychosocial law of social impact theory argues that people do not pay the same levels of attention to all opinions at all times. When this assumption is introduced, it becomes necessary to modify the agents' change rule accordingly.

The changes in an agent's decision rule may also change the effects of an agent's expertise and power and status on organizational-level choices. The change rule based on the psychosocial law reflects differences among agents in terms of their expertise and power and status. However, the change rule causes agents to assign greater weight to the opinions of counterparts with whom they contact earlier than others, for example. Under this condition, agents' choices may be determined by the opinions of counterparts whose order of interaction is earlier even if those counterparts' power and status is lower than others' power

and status. In other words, the law and decision rule likely reduce the influence of non-experts and agents with higher power and status in determining organizational-level choices of action or inaction.

According to social impact theory, three factors and one law determine the influence that a person receives from others[14]. First, the three factors are the strength or the impact that others have on a person ("social strength"), immediacy of others to the person (distance in time and space), and the number of others (the number of bystanders). The amount of influence is a multiplicative function of these factors. In the models of this dissertation, these factors are linked to agents' attributes and interactions as follows. Agents' strength depends on whether their expertise matches the field of potential problems and/or whether they have higher, the same, or lower power and status than their counterparts. The immediacy is determined by the order of interactions between an agent and other agents. Finally, the number of others is the number of the agent's counterparts as a whole in each round of interactions.

Then, the law that also determines the influence is called the "psychosocial law" (Latané 1981). It follows a power function and states that the total amount of influence that a person receives from others will continue to marginally increase as the number of others increases. I explain this law in detail below.

The psychosocial law is an application of Stevens' psychophysical law (Stevens 1966) to social psychology. Stevens attempts to determine how human subjectivity influences their perception of physical strength, such as their responses on the saltiness of a

[14] There is a third principle in social impact theory, called "division of impact". However, the principle is beyond the scope of this dissertation because it concerns how a target experiences influence from multiple sources when there are other multiple targets of the influence. In terms of an agent's decision rule, there is always only one target, that is, the agent.

type of salt. The finding is the psychophysical law, $\Psi = k\Phi^{\wedge}\gamma$, where Ψ is a subjective evaluation of the strength, k is a scaling constant to measure the strength, Φ is an actual strength, and γ is a power less than 1. The law suggests that differences between responses by human subjects, for example, on saltiness, continuously decrease as the number of trials increases. Latané finds that the same law is applicable to the influence that a person feels from others, termed as the psychosocial law (Latané 1981). The law is expressed as $I = sN^{\wedge}p$, where I is the total amount of social impact, s is a scaling constant of the impact, N is the number of others, and p is a power that is less than 1. With the equation, the total amount of social impact that a person receives continues to only marginally increase as the number of others increases.

The three factors and psychosocial law of social impact theory imply the following with respect to the change rule in the models of this dissertation. First, agents exchange their influence whose values are a multiplicative function of the match of their expertise and/or power and status (social strength), the order with which they interact (distance in time and space), and the number of counterparts with which they interact. Thus, for an individual counterpart's influence, the equation is $I_{ci} = g(E_{ci} + PS_{ci}, R_{ci}, 1/CI) = (E_{ci} + PS_{ci}) * R_{ci} * 1/CI$, where I_{ci} is a counterpart's influence, E_{ci} is the match of expertise of a counterpart, PS_{ci} is a counterpart's power and status, R_{ci} is the j^{th} order for a counterpart to interact with an agent, and CI is the number of counterparts.

Second, the total influence that an agent receives from all of its counterparts only marginally increases as the number of its counterparts increases, which indicates that values of $\overline{I_{ci}} = \sum_{ci=1}^{CI} I_{ci} / CI$ and those of $\sum_{ci=1}^{CI} I_{ci}$ must exponentially decrease when an agent interacts with greater numbers of counterparts. To satisfy this condition, the above function

I_{ci} must be modified into $I_{ci} = [(E_{ci} + PS_{ci}) * R_{ci} * 1/CI]*exp\text{^}(-\zeta * j_{ci})$, where j_{ci} is the order of a counterpart's interaction with an agent. As the value of ζ decreases, the curve of the exponential function becomes less steep. Thus, greater numbers of counterparts can influence an agent, which indicates that an organization is more open to speaking up and taking action because interactions more frequently occur in the organization. The appropriate value of the parameter is $\zeta = \{0.1, 0.2, \ldots, 0.9\}$.

In addition, R_{ci} can be converted into $CI - j_{ci} + 1$ for the following reasons. First, it is inferred from social impact theory that a counterpart's influence increases if the counterpart interacts with an agent earlier than other counterparts, in other words, the counterpart has a greater immediacy to the agent. Second, the first reason demands a vector of values of influence given by the order of interactions $\mathbf{v} = \{CI, CI - 1, CI - 2, \ldots, 1\}$ and a set of order of interactions $j = \{1, 2, \ldots, CI\}$. The relation between $\mathbf{v}$ and j is $h(\mathbf{v}, j) = CI - j + 1$. Due to this conversion, the equation becomes $I_{ci} = [(E_{ci} + PS_{ci}) * (CI - j_{ci} + 1) * 1/CI] * exp\text{^}(-\zeta * j_{ci})$.

One additional conversion is necessary for the above equation. In the ABMs in this chapter, the possible maximum value of PS_{ci} is 50 because an agent's power and status is defined as $PS_i = PS_{fi} * PS_{infi}$, where $PS_i = [1, 10]$ and $PS_{infi} = [1, 5]$. Such large values of PS_{ci} cause values of I_{ci} to increase in an unrealistic manner. Thus, it is necessary to convert the values of PS_{ci} into more appropriate values, which are between 0.0 and 1.0. For this conversion, PS_{ci} in the above equation must be changed into $(PS_{ci} * 2)/100$, which makes $I_{ci} = [(E_{ci} + PS_{ci}/50) * (CI - j_{ci} + 1) * 1/CI] * exp\text{^}(-\zeta * j_{ci})$.

How does the influence of counterparts then determine the change rule with which an agent takes into account their opinions? In other words, what is the relationship among an

agent's opinion value after a round of interactions (AO_i), a counterpart's opinion value in the round of interactions (O_{ci}), and the above equation?

To answer these questions, it is necessary to consider the characteristics of an organization that the second and third groups of social psychological studies have explained in Chapter 3. If an organization has a favorable environment to speak up and take action against potential problems, not only can all individuals speak up but they will also be heard. A member's expertise or power and status does not impact his/her influence. In such an organization, E_{ci} and PS_{ci} are unimportant and the equation in this case becomes $I_{ci} = [(CI - j_{ci} + 1) * 1/CI] * exp\text{^}(-\zeta * j_{ci})$. The impact of a counterpart's opinion value in a round of interactions, IO_{ci}, consists of the counterpart's opinion value and influence. Thus, $IO_{ci} = O_{ci} * [(CI - j_{ci} + 1) * 1/CI] * exp\text{^}(-\zeta * j_{ci})$. An agent's opinion value after a round of interactions is $AO_i = \left(O_i * IO_i + \sum_{ci=1}^{CI} IO_{ci}\right) / \left(IO_i + \sum_{ci=1}^{CI} I_{ci}\right)$, where $IO_i = 1$.

As an organization becomes less open to speaking up and taking action, the match of counterparts' expertise and their power and status begin to intervene in an agent's decision. In one case, the agent considers a counterpart's expertise in determining whether to take into account the counterpart's opinion value. In this case, a counterpart's influence becomes $I_{ci} = [E_{ci} * (CI - j_{ci} + 1) * 1/CI] * exp\text{^}(-\zeta * j_{ci})$ and the impact of its opinion value to an agent becomes $IO_{ci} = O_{ci} * [E_{ci} * (CI - j_{ci} + 1) * 1/CI] * exp\text{^}(-\zeta * j_{ci})$. In an organization far less open to speaking up and taking action, the agent must consider not only a counterpart's expertise but also the counterpart's power and status. Consequently, the expertise is comparatively insignificant. In the organization, a counterpart's influence becomes $I_{ci} = [(E_{ci} + PS_{ci}/50) * (CI - j_{ci} + 1) * 1/CI] * exp\text{^}(-\zeta * j_{ci})$ and the impact of its opinion value to an agent is $IO_{ci} = O_{ci} * [(E_{ci} + PS_{ci}/50) * (CI - j_{ci} + 1) * 1/CI] * exp\text{^}(-\zeta * j_{ci})$.

In short, an agent adopts an opinion value after a round of interactions so that $AO_i = \left(O_i * IO_i + \sum_{ci=1}^{CI} IO_{ci}\right) / \left(IO_i + \sum_{ci=1}^{CI} I_{ci}\right)$ and the value of IO_{ci} changes as follows depending on an organization's openness to speaking up and taking action:

Change Rule 1: $AO_i = \left(O_i * IO_i + \sum_{ci=1}^{CI} IO_{ci}\right) / \left(IO_i + \sum_{ci=1}^{CI} I_{ci}\right)$, where $IO_i = 1$, $IO_{ci} = O_{ci} * [(CI - j_{ci} + 1) * 1/CI] * exp\text{^}(-\zeta * j_{ci})$, and $I_{ci} = [(CI - j_{ci} + 1) * 1/CI] * exp\text{^}(-\zeta * j_{ci})$,

Change Rule 2: $AO_i = \left(O_i * IO_i + \sum_{ci=1}^{CI} IO_{ci}\right) / \left(IO_i + \sum_{ci=1}^{CI} I_{ci}\right)$, where $IO_i = 1$, $IO_{ci} = O_{ci} * [E_{ci} * (CI - j_{ci} + 1) * 1/CI] * exp\text{^}(-\zeta * j_{ci})$, and $I_{ci} = [E_{ci} * (CI - j_{ci} + 1) * 1/CI] * exp\text{^}(-\zeta * j_{ci})$, and

Change Rule 3: $AO_i = \left(O_i * IO_i + \sum_{ci=1}^{CI} IO_{ci}\right) / \left(IO_i + \sum_{ci=1}^{CI} I_{ci}\right)$, where $IO_i = 1$, $IO_{ci} = O_{ci} * [(E_{ci} + PS_{ci}/50) * (CI - j_{ci} + 1) * 1/CI] * exp\text{^}(-\zeta * j_{ci})$, and $I_{ci} = [(E_{ci} + PS_{ci}/50) * (CI - j_{ci} + 1) * 1/CI] * exp\text{^}(-\zeta * j_{ci})$.

Thought Experiments on the Effects of the Psychosocial Law. To examine how the psychosocial law affects the findings on those who are given the most attention but give the least attention to others and on organizational-level choices, in this section, I perform thought experiments with the following conditions. First, agents have all three attributes: opinions, match of expertise, and power and status. These three attributes are necessary because the equation of Change Rule 3 includes all of these attributes and the outcomes due to differences between the change rules must be compared with each other. Second, only agents with match of expertise initiate interactions, following Initiating Rule 2. Third, at the beginning, all agents interact with all others that they encounter, that is, they follow Search Rule 1. Thus, power and status differences are unimportant when they select their counterparts to discuss potential problems. Then, the differences are introduced and agents select counterparts with higher power and status, following Search Rule 3, or they select

counterparts with the same power and status, following Search Rule 4. Finally, agents follow Change Rule 1 to 3 in different models, whose effects are compared one by one both in the symmetric and random world. Table 3 of Appendix B describes the models of these thought experiments. Table 4 lists the agents' decision rules.

In the models, Initiating Rule 2 has been chosen for two reasons. First, if all agents initiate interactions regardless of their expertise, it will be difficult to compare how the psychosocial law impacts the influences of opinions held by experts and non-experts. Second, if all agents interact with all other agents regardless of their power and status, it is predictable that opinions at the individual level will converge to the mean of the original opinions and, thus, the organizational-level choices will become 0.0. This convergence and choice occur because agents calculate the weighted means of opinions of their counterparts. When the outcome seems to be clearly predictable, no further experiments are worthwhile.

In addition, Search Rules 3 and 4 have been chosen for the same reasons. Organizational-level choices show the same pattern when agents select counterparts with the same and higher power and status (Search Rule 2) and when they select counterparts with higher power and status (Search Rule 3). In both cases, those with higher power and status cause others' opinions to shift toward theirs. In contrast, in Chapter 4 and the previous sections in this chapter, when agents discuss problems only with their peers, following Search Rule 4, opinions cluster among peers and those with many peers have a larger influence on organizational-level outcomes. It is worthwhile to examine whether these findings hold under the condition with the psychosocial law.

Thus, I begin the experiments with the symmetric world in which agents follow Initiating Rule 2, Search Rule 1, and Change Rule 1 and then switch the change rules into

Change Rules 2 and 3 one by one. In Table 3, these conditions constitute ABMs 48 to 50. Next, I examine the outcome in the random world in which agents' opinions and expertise distribute in an uneven manner. In these models (ABMs 51 to 53 in Table 3), agents follow the same rules as those in the symmetric world so that it is possible to clarify the effects of biases introduced into the random world. Finally, I examine the effects of power and status differences (ABMs 54 to 59 in Table 3). The thought experiments in this section generate three outcomes. First, non-experts become influential in determining organizational-level choices in some models[15]. Second, in other models[16], any agents with higher power and status become more influential than other agents regardless of their expertise. Finally, in the remaining models[17], the opinions of experts determine organizational-level choices, which is new to the findings of Chapter 4. I explain how these differences emerge in the following paragraphs.

First Outcome: Non-Experts as Influential Agents. Non-experts have been influential agents who determine organizational-level choices in Chapter 4; thus, this outcome is not new. However, it is necessary to explain how the non-experts become influential under the condition with the psychosocial law. The influence of non-experts is the same in the symmetric and random world. As in the previous sections on the feedback mechanism and potential embarrassment, agents' opinions and match of expertise distribute in a uniform manner in the symmetric world of this section. The opinions distribute in a uniform distribution, $O \sim U(-1, 1)$, and the match of expertise is assigned to agents with a binomial distribution, $B(1, 0.5)$. I assume that the formal power and status of agents follows a power-law distribution, as in Figure 5.1, and informal power and status is randomly

[15] These models are ABMs 45, 47, 48, 50, 51, 53, 54, 55, 58, and 59 in Table 3.
[16] These models are ABMs 54 and 58.
[17] These models are ABMs 46, 49, 52, 56, and 57.

distributed. The values of agents' power and status, as previously explained, are products of their formal and informal power and status. In the random world, an agent with or without match of expertise, i.e., an expert or a non-expert, is added to the models.

In both of the worlds, the opinions of non-experts become influential under the condition that agents follow Change Rule 1 or Change Rule 3. I explain how these rules make non-experts influential. At the beginning, take the symmetric world with Change Rule 1 as an example. In the world, all agents with match of expertise initiate interactions (Initiating Rule 2) and half of all agents become such experts due to the binomial distribution of the attribute. Agents are not selective in terms of counterparts' power and status (Search Rule 1). They simply take into account the opinions of any counterparts as they interact one by one. However, due to the diminishing effect that the psychosocial law in Change Rule 1 dictates, that is, $I_{ci} = [(CI - j_{ci} + 1) * 1/CI] * exp\text{^}(-\zeta * j_{ci})$, the opinions that an agent encounters later have exponentially smaller impact than those that they encounter earlier. For example, even if both the first and second counterparts of an agent have original opinions, 1.0, the impact of the first counterpart will be 0.607 and that of the second counterpart will be 0.353, which is calculated with the value of the parameter $\zeta = 0.5$. Under the condition, agents are quicker to determine their new opinions than under the condition with the parameter value, for example, 0.1. Regardless of the parameter value, an agent's attention attenuates as its interactions continue, and this attenuation is an effect of the psychosocial law.

In this model, experts' opinions converge toward the mean of all agents' original opinions, 0.0, because they calculate the weighted mean of those opinions following the change rule, $AO_i = \left(O_i * IO_i + \sum_{ci=1}^{CI} IO_{ci}\right) / \left(IO_i + \sum_{ci=1}^{CI} I_{ci}\right)$. However, their opinions do

not perfectly converge to the mean, and the outcome differs from that in the symmetric world in the previous sections. The convergence does not occur because non-experts neither initiate interactions nor change their opinions. The opinions of the non-experts, which distribute from -1.0 to 1.0, cause the opinions of experts to disperse from the exact mean. In this regard, three forces are working in this model. The first force, the term for the weighted mean of the change rule, works for partial convergence of agents' opinions. The second force, non-experts' opinions, works for dispersion of those opinions. Finally, the third force, all the terms of the change rule, works in both ways. This force helps agents' opinions to converge toward the mean because of the attenuation effect that causes the impact of counterparts' opinions to reduce toward 0.0 as interactions among agents continue. This force also prevents those opinions from perfectly converging because it complicates how counterparts' opinions may change experts' opinions in the following manner.

First, experts weigh their counterparts' opinions based on the impact of those opinions. In the change rule, the impact is determined by the order of encounters between agents and diminishing rates of the weights of the counterparts' opinions, and the diminishing rates are based on the order. Depending on the impact, experts' opinions continue to change as interactions continue. Second, however, as interactions continue, the diminishing rates become exhaustive against experts' opinions, which have begun converging toward the mean, more than against non-experts' opinions. Although the term of the impact in the change rule is constant if the order of encounters and the diminishing rates are the same, experts' opinions continue to move even closer toward the mean. Third, the impact of non-experts' opinions remains the same because these agents do not join interactions and their opinions do not change. In other words, the weights of non-experts'

opinions continue to grow compared to those of experts' opinions as interactions continue. Furthermore, the comparatively and constantly growing influence of non-experts' opinions does not allow experts' opinions to converge to the exact mean of their original opinions. As a result, experts' opinions continue to fluctuate around the mean, 0.0, but never settle on it.

These forces determine individual- and organizational-level outcomes. As previously mentioned, at the individual level, experts' opinions converge toward approximately 0.0, whereas non-experts' opinions remain unchanged. At the organizational level, the outcome eventually becomes approximately 0.0 because the mean of non-experts' and experts' opinions is 0.0 in the symmetric world. However, because the converging and dispersing forces are working together, the organizational-level choice continues to fluctuate at approximately 0.0. In short, the simplest form of the psychosocial law, which is operationalized as Change Rule 1, prevents organizational-level choices from quickly settling on the mean even in the symmetric world. This outcome differs from that in the thought experiments in the previous sections. In addition, the opinions of non-experts who do not join discussions on potential problems are the source of the difference.

The above outcomes have shown that by introducing the psychosocial law and accordingly altering agents' change rules, the organizational-level choices become less deterministic in terms of what to do against potential problems even in the symmetric world. In the previous sections in which feedback to agents and potential embarrassment are introduced into the symmetric world, organizational-level choices are always 0.0 sharp and agents quickly make the decision. In addition, once the agreement is reached, it never fluctuates. In contrast, in the thought experiments thus far, a specific decision is difficult to reach and organizational-level opinions continue to fluctuate, although the fluctuations occur

at approximately 0.0. In other words, when agents do not pay full attention to counterparts' opinions due to the psychosocial law, the indeterminacy occurs at the organizational level even in the symmetric world.

Then, what occurs when organizational conditions to speak up and take action become stricter with Change Rule 3? With the change rule, experts take into account counterparts' power and status, which is PS_{ci} in $I_{ci} = [(E_{ci} + PS_{ci}/50) * (CI - j_{ci} + 1) * 1/CI] * exp\text{^}(-\zeta * j_{ci})$. Thus, even if an expert's counterpart is a non-expert, which indicates that its $E_{ci} = 0$, the impact of the counterpart's opinion does not become zero. Under this condition, the impact of non-experts is retained with their power and status, PS_{ci}, although E_{ci} of non-experts reduces the impact of their opinions compared to those of experts. In addition, whereas experts' opinions converge toward approximately 0.0 as interactions continue, non-experts' opinions do not change. Thus, due to the constant values of the impact of an individual agent's opinion, the impact of non-experts' opinions does not change, whereas that of experts' opinions continuously decreases. As a result, non-experts' opinions continue to disperse experts' opinions at approximately 0.0 and prevent them from settling on exactly 0.0.

A difference from the models in which experts do not take into account counterparts' power and status (Change Rule 1) is the degree of the dispersion. With Change Rule 1, the values of impact of counterparts' opinions are determined by the order of encounters and the diminishing rates that define how an agent's attention attenuates. When experts take into account counterparts' power and status (Change Rule 3), in addition to the above two factors, the values depend on counterparts' match of expertise and their power and status. For non-experts, the values of their match of expertise are zero. In addition, the values of their power and status are cut in half by $PS_{ci}/50$ so that the values fall between 0.0 and 1.0, as explained

in the paragraphs on the psychosocial law. Thus, with the equation of Change Rule 3, the impact of non-experts' opinions becomes smaller than that calculated with the equation in Change Rule 1. For example, if a non-expert is the first encounter of an expert, the opinion value of the former is 1.0, and the value of the parameter ζ is 0.5, then the impact of the non-expert's opinion is 0.607, as described in the paragraphs on the thought experiment with Change Rule 1. With Change Rule 3, if the value of $PS_{ci}/50$ of the non-expert is, for example, 0.99, the impact of its opinion is 0.600. If the value of $PS_{ci}/50$ is 0.5, the impact is 0.303. Therefore, non-experts' opinions exert similar dispersing forces, but the forces are weaker than those with Change Rule 1. As a result, the degrees of fluctuation of the experts' opinions decrease, which decreases the fluctuations of organizational-level opinions around 0.0.

Even in the random world, non-experts maintain their influence if agents follow the two change rules. For example, consider the case in which agents disregard counterparts' power and status, following Change Rule 1. If the added agent is an expert, the agents' opinions change as follows. Once the added agent, who is an expert, joins discussions about potential problems (Initiating Rule 2) and interacts with all other agents (Search Rule 1), its opinion begins to move toward 0.0. Although the mean of all agents' original opinions may not be 0.0 depending on the added agent's original opinion, the difference is cancelled as interactions continue due to the impact term of the change rule. In addition, the opinions of non-experts, which evenly distribute between -1.0 and 1.0 and never change because they do not join discussions (Initiating Rule 2), continue to exert forces that disperse experts' opinions. Thus, as occurred in the symmetric world, not only experts' opinions but also the mean of all agents' opinions eventually converge toward approximately 0.0; however, their values continue to fluctuate around the value.

If the added agent is a non-expert, the agent does not initiate interactions; thus, its opinion does not change. On the other hand, experts' opinions converge toward approximately the mean of all agents' original opinions but continue to fluctuate due to the dispersing forces of non-experts' opinions. However, the mean may not be 0.0 depending on the non-expert's original opinion. If the value of the opinion is greater than 0.0, the mean shifts toward 1.0. In contrast, it shifts toward -1.0 if the value is less than 0.0. Thus, experts' opinions may fluctuate around greater or lesser values than 0.0. Because the added non-expert does not join interactions (Initiating Rule 2) and its opinion does not change, the shift never disappears regardless of interactions among experts.

In the models in which agents consider counterparts' power and status (Change Rule 3), if an added agent is an expert, their opinions begin to converge toward approximately 0.0 following the impact term of the change rule. Although the value of the added agent's original opinion may shift the mean of all experts' opinions toward a greater or lesser value than 0.0, the gap is cancelled as interactions continue. However, their opinions continue to fluctuate due to the dispersing forces of non-experts' opinions, which never change. In addition, the degrees of fluctuation are smaller than those in the model in which agents disregard counterparts' power and status (Change Rule 1) because the impact of non-experts' opinions depends on the value of their $PS_{ci}/50$ if agents follow Change Rule 3, as occurred in the symmetric world.

If the added agent is a non-expert, its opinion does not change but exerts forces that disperse experts' opinions. Because of these forces, experts' opinions continue to fluctuate. As in other models with an added expert, experts' opinions converge toward approximately 0.0. The convergence occurs because the impact term of the change rule reduces the

influence of other experts' opinions as interactions continue. In addition, experts take into account all other agents' opinions (Search Rule 1), including those of non-experts; thus, the non-experts' opinions affect how experts' opinions change. However, the impact term of the change rule also mitigates the effect by reducing the weights of non-experts' opinions based on the order of encounters and the non-experts' power and status. Therefore, at the individual level, each expert that interacts with the added non-expert first experiences almost unmitigated, utmost impact of its opinion. However, the value of the impact tends to be less than 1 due to $E_{ci} = 0$ and $0.0 \leq PS_{ci}/50 \leq 1.0$. In contrast, as a collective of experts, experts are exposed to the collective effect of other agents' opinions that are larger than that of the added non-expert's opinion and the mean of original opinions due to the non-expert's addition because the weighted mean is calculated with the change rule and its impact term in which experts have $E_{ci} = 1$. Because the mean of the other agents' opinions is 0.0, the experts' opinions converge toward around 0.0.

At the organizational level, the outcome does not settle on a value; rather, it continues to fluctuate due to the fluctuations of the new opinions of experts. However, as occurred in the symmetric world, compared to the fluctuations in the model in which agents disregard counterparts' power and status (Change Rule 1), the degrees of fluctuation are smaller because they take into account the attribute to determine their new opinions (Change Rule 3).

In the thought experiments thus far, once agents become initiators, they interact with any others. This is because in those experiments, they choose any other agents as their counterparts regardless of those agents' power and status (Search Rule 1). I also consider cases in which agents select their counterparts based on the power and status of those counterparts. In some models, agents select those with higher power and status as their

counterparts to discuss potential problems (Search Rule 3). In other models, they select those with the same power and status as their counterparts (Search Rule 4). Under these conditions, non-experts remain influential agents if agents follow Change Rules 1 and 3. However, the change in agents' search rule leads to slight variations in the influence.

When agents select counterparts with higher power and status (Search Rule 3), the opinions of non-experts remain influential if a non-expert is added to create the random world. The influence of non-experts is not affected by which of the two change rules (Change Rules 1 and 3) agents follow[18]. First, consider the case in which agents disregard counterparts' power and status when they develop new opinions through interactions, which is Change Rule 1. When the added agent is a non-expert, it does not join interactions and its opinion never changes. At the individual level, experts' opinions continue to fluctuate due to the change rule and opinions of non-experts. At the organizational level, the power and status of the non-expert influences outcomes due to Search Rule 3.

For example, if the power and status of the non-expert is the highest and its opinion is 1.0 or -1.0, the mean of all agents' opinions after interactions shifts toward the opinion. If the power and status is the lowest, the mean does not shift to its opinion as much. If the original opinion of the non-experts is approximately 0.0, the shift does not occur to a discernible extent regardless of its power and status. In addition, the fluctuation of the mean also becomes smaller than otherwise. Thus, depending on the two attributes of the added non-expert, which are its opinion and power and status, organizational-level choices move toward the direction of pro-action or anti-action. The non-expert becomes more influential than other agents if its power and status is higher than those of others in this model. If agents consider counterparts' power and status when they develop new opinions (Change Rule 3), non-

[18] For the details of agents' decision rules, see ABMs 54 and 58 in Table 3.

experts exert an impact because of the term PS_{ci} in the equation of the change rule, although the total values of the impact are less than those of experts, which is $1 + PS_{ci}$. The impact of non-experts' opinions also generates dispersing forces of their opinions. Thus, experts' opinions continue to fluctuate at the individual level, and the fluctuations lead to fluctuations of the mean of all agents' opinions at the organizational level.

When agents select counterparts with the same power and status (Search Rule 4), non-experts without peers have the largest impact at individual and organizational levels. This is because their opinions never change, whereas experts take into account the opinions of others. In this model, experts consider peers' opinions only. Thus, if non-experts, including the added non-expert, have the same power and status as experts, their opinions influence those experts at the individual level and collective choices at the organizational level. If non-experts have no peers, experts do not take into account their opinions. In this regard, the influences of those opinions to experts are smaller than otherwise. However, those opinions determine organizational-level choices. A caveat about the influence of non-experts is that the impact is disturbed by the factors in the change rule, such as the order of encounters and diminishing impact of counterparts' opinions.

The influence of non-experts' opinions does not change even if an expert is added to create the random world. If the added agent is an expert, its opinion continues to move toward 0.0 due to the change rule. In addition, the search rule in the model, Search Rule 4, determines how the added agent's power and status and its opinion influence the individual- and organizational-level choices by agents in two ways. First, because initiators interact only with counterparts with the same power and status, influences from counterparts' opinions are more limited than those with Search Rule 3. Whether the counterparts are experts or non-

experts, the added agent interacts with a smaller number of counterparts. If all of the counterparts are experts, all of their opinions change to 0.0, and the order of encounters and their original opinion values provide a little variety among their new opinions. If some of the counterparts are non-experts, the opinions of all experts, including the added agent, converge to 0.0; however, the order of encounters and opinions of the non-experts determine how close the experts' opinions move to 0.0. In addition, due to the dispersing forces of non-experts' opinions, experts' opinions continue to fluctuate. However, the degrees of fluctuation are smaller than those with Search Rule 3 because experts interact with non-experts only if the latter have the same power and status. Unless the opinions of those non-experts evenly distribute from -1.0 to 1.0, experts' opinions fluctuate in a range closer to the opinions of the non-experts.

At the organizational level, agents' choices are determined by the opinions of non-experts who have no peers, that is, agents who do not initiate interactions and have no others with the same power and status. In this model, experts' opinions move toward 0.0 and the movements occur partly due to the impact of the opinions of non-experts whose power and status is the same as those of the experts. However, non-experts without peers are excluded from the interactions and the experts' considerations on their new opinions. As a result, the opinions of the non-experts and their impact remain intact and the mean of all agents' opinions after rounds of interactions become increasingly closer to the opinions of those non-experts. If those opinions evenly distribute between -1.0 and 1.0, the mean becomes 0.0; otherwise, it shifts to either -1.0 or 1.0.

Second Outcome: The Powerful as Influential Agents. In some of the thought experiments, agents become influential in determining organizational-level choices

regardless of their expertise, in other words, whether they are experts or non-experts. However, three conditions determine the influential agents. The first condition is the random world to which an expert is added. The second condition is that agents select their counterparts with higher power and status (Search Rule 3). The third condition is that, because of the search rule, agents must have higher power and status than others. If these conditions are satisfied, which of the two change rules agents follow is unimportant.

In the relevant models[19], the expert joins discussions about potential problems and its opinion begins to change as soon as interactions are initiated. Following the search rule, experts including the added agent select counterparts with higher power and status. Thus, in addition to the added expert's original opinion, the agents' power and status determines its influence on organizational-level choices. For example, if the value of the added agent's power and status is 1, the smallest value of all, the added agent takes into account the opinions of all other agents. In contrast, as its power and status increases, its opinion begins to influence the other experts' opinions, but others' opinions do not affect its own opinion. The same mechanism works for other agents' power and status.

Under the condition, agents' opinions behave in the following manner at the individual and organizational levels. The added agent's opinion joins other agents' opinions that converge toward 0.0, and the convergence depends on three factors. First, it depends on the agent's power and status. As the power and status becomes lower, the agent interacts with more counterparts in a round of interactions. The opinions of those counterparts push the agent's opinion toward 0.0, although the mean of original opinions of all agents is not 0.0 unless the original opinion of the added agent is 0.0. Second, how the agent's opinion changes also depends on the order of encounters with its counterparts. For example, assume

[19] These models are ABMs 54 and 58. For details, see Table 3.

that another agent has the same value of power and status as that of the added agent. The two agents' opinions will become different after interactions if one of them interacts earlier than the other does with counterparts whose opinion values are larger or smaller than those of the other agent's counterparts. Third, the value of its original opinion influences the move because the impact of an agent's own opinion is always 1 in the equation of the change rule, as $IO_i = 1$ in $AO_i = \left(O_i * IO_i + \sum_{ci=1}^{CI} IO_{ci}\right) / \left(IO_i + \sum_{ci=1}^{CI} I_{ci}\right)$. It is more likely that the added agent's opinion is larger if its original value is greater than 0.0. Due to this mechanism, unless the added agent has the highest power and status among all agents, its opinion changes toward 0.0 with other experts' opinions. In other words, although the original opinion of the added agent is important to a certain extent, the factor is not as significant as the power and status of the added agent.

In the process, as occurred in other cases in the random world, the values of non-experts' opinions and the change rule exert dispersing forces so that experts' opinions do not settle on 0.0. Thus, experts' opinions continue to fluctuate around this value. As non-experts' opinions become far from the mean and their power and status becomes higher than the power and status of experts, the degrees of fluctuation become larger. For example, if the power and status of all non-experts is higher than those of all experts and if the opinions of half of the non-experts are 1.0 and those of the other half are -1.0, experts' opinions, while they are converging toward 0.0, continue to be pulled toward the two extreme opinion values. If the opinions of those non-experts are approximately 0.0, the experts' opinions are more likely to converge toward this value. In contrast, if all experts have higher power and status than all non-experts, experts do not take into account the opinions of non-experts and experts' opinions continue to fluctuate only because of the change rule.

Therefore, the opinions of agents with higher power and status have a larger impact than other agents' opinions. However, due to the change rule, such factors as the order of encounters and diminishing impact of counterparts' opinions intervene in the impact of agents' power and status. Thus, individual opinions are also affected by attenuation of experts' attention to counterparts' opinions. As a result, at the individual level, experts' opinions continue to fluctuate, as demonstrated in other models. At the organizational level, agents' choices converge toward 0.0, but the value of their choices also continues to fluctuate. In other words, it is difficult for members to agree on clear directions for their collective actions.

Third Outcome: Experts as Influential Agents. Introducing the psychosocial law and its attenuation effect on agents' attention generates a new outcome to the findings of the minimalist models in Chapter 4. In some cases, experts become influential in determining organizational-level outcomes. Experts become influential when agents take into account counterparts' power and status and their match of expertise in developing new opinions (Change Rule 2). The impact term of the rule incorporates counterparts' match of expertise as a factor, which is E_{ci} in $I_{ci} = [E_{ci} * (CI - j_{ci} + 1) * 1/CI] * exp\text{^}(-\zeta * j_{ci})$. Because of the term, experts disregard the opinions of non-experts because E_{ci} of non-experts is zero and, thus, the impact of non-experts' opinions also becomes zero. In other words, experts take into account other experts' opinions only. The addition of the factor also cancels the dispersing force of non-experts' opinions at the organizational level. As a result, experts' opinions eventually converge toward 0.0 and then never fluctuate at the individual level, which also determines the organizational-level choice because the mean of all non-experts' opinions is also 0.0. Thus, under this condition, non-experts' influence on organizational-level choices is not as

great as in previous models. In addition, non-experts are not given the most attention, although they give the least attention to others. In contrast, experts appreciate other experts' opinions only, and their opinions determine organizational-level outcomes.

This outcome is the same in both the symmetric and random world, especially if an expert is added to create the random world. In this case, all initiators, including the added agent, practically disregard non-experts' opinions because of the change rule. In addition, regardless of the original opinion of the added agent, experts' opinions converge toward 0.0 as interactions continue due to the diminishing rate of counterparts' opinions, as determined by the impact term of the change rule. The mean of non-experts' opinions is 0.0; thus, organizational-level choices eventually settle on 0.0 without the dispersing forces of non-experts' opinions as observed above.

However, if the added agent is a non-expert, its opinion value determines organizational-level choices as follows. First, the agent does not initiate interactions and join discussions; thus, its opinion does not change. Second, experts' opinions converge toward 0.0 because of the change rule. As a result, at the organizational-level, choices become equal to the mean of the non-experts' original opinions. In other words, the added non-expert's opinion determines the organizational-level outcome.

Experts retain their influence even if agents select their counterparts based on others' power and status. Under this condition, the impact of non-experts' opinions remains zero. Therefore, with all other conditions held constant, power and status differences among experts determine individual and organizational choices. Thus, if the added agent is an expert, its opinion and power and status determine individual- and organizational-level outcomes in the following manner.

When agents select counterparts with higher power and status (Search Rule 3), experts with lower power and status have more counterparts than those with higher power and status. Thus, in a round of interactions, they receive a greater impact from others' opinions. Due to the change rule, the impact becomes smaller as the order of encounters with those counterparts becomes larger in a round. Thus, as those experts repeat interactions, their opinions become increasingly closer to 0.0. How close the opinions move depends on the values of their original opinions. In contrast, as experts' power and status becomes higher, the number of their counterparts decreases, and the movements of their opinions toward 0.0 also become smaller. If a counterpart of the added expert has the highest power and status, the counterpart's opinion never changes. In this case, the original opinion of the added expert does not impact individual and organizational choices. At the beginning, the opinion shifts the mean of all experts' opinions toward its value, but the diminishing term of the change rule eventually cancels the shift. Organizational-level choices move toward the opinion of the expert with the highest power and status. If the added expert has the highest power and status among all agents, its opinion determines other experts' individual opinions and organizational-level choices.

Unless the opinion of the added expert is 0.0, the opinions of experts may continue to fluctuate even if the impact of non-experts' opinions is zero due to the change rule. If experts interact with others regardless of their power and status (Search Rule 1), experts' opinions converge toward 0.0 and no fluctuations occur afterwards. Because all experts interact with each other, the values of their opinions move toward 0.0 due to the diminishing impact of counterparts' opinions for the change rule, and non-experts' opinions do not have an impact because of the change rule. However, if experts limit their interactions to those with higher

power and status (Search Rule 3), at least one expert (i.e., the expert with the highest power and status among all experts) does not change its opinion. Therefore, the opinion exerts dispersing forces that non-experts' opinions generate in the models with Change Rules 1 and 3. The degrees of fluctuation depend on the value of the opinion and distance of other experts' opinions from 0.0. However, because the opinions of those experts come closer with each other due to the diminishing term of the change rule and the impact of non-experts' opinions is cancelled for Change Rule 2, the degrees seem to become smaller than those in the models with other change rules. Fluctuations in organizational-level choices, in other words, collective agreements on what to do against potential problems, or lack thereof, depend on the degrees of fluctuation of individual-level opinions.

In short, experts with higher power and status become influential in determining organizational-level choices under the condition in which agents interact with counterparts who possess higher power and status and the impact term of the change rule incorporates the counterparts' match of expertise in addition to their power and status.

When agents select counterparts with the same power and status (Search Rule 4), the opinion of an added expert impacts organizational-level outcomes if the agent has no counterparts with the same power and status. Otherwise, its opinion changes through interactions following the change rule and moves toward 0.0. If the agent has no such counterparts, its opinion contributes to move the mean of all agents' opinions after interactions, that is, organizational-level choices, away from 0.0. Under this condition, the opinions of experts who do not have peers determine organizational-level choices.

The degrees of fluctuation of experts' opinions may be far smaller than those with Search Rule 3. The degrees may be nearly none. With Search Rule 3, experts take into

account all other experts' opinions if the latter have higher power and status. Thus, if at least one expert has the highest power and status and its opinion is extremely greater or lesser than 0.0, the expert's opinion continues to influence all other experts' choices such that they fluctuate. In contrast, with Search Rule 4, experts disregard the opinions of those with lower or higher power and status. Therefore, the opinions of such agents render no impact. In addition, experts who have counterparts with the same power and status continue to change their opinions among the peers, and the changes cause their opinions to move toward 0.0 due to the order of encounters and the diminishing term of impact of the opinions for the change rule. Therefore, even if the added expert has counterparts and its opinion has an extreme value, the fluctuations of experts' opinions, if any, tend to occur within very small ranges around 0.0 compared to those with Search Rule 3.

Summary of the Effects of the Psychosocial Law. Based on social impact theory, the psychosocial law in the models of this section reflects how members' attention to others' opinions attenuates as interactions continue. In the real world, attention is a limited resource. Thus, an opinion that is encountered later than other opinions may have a smaller impact on the member. In addition, if a member is repeatedly exposed to similar opinions, the impact of those opinions diminishes as interactions continue. The three change rules incorporate these attenuation effects into the models. The rules also reflect organizational conditions to speak up on and take action against potential problems. As the rule changes from the first to the third, the conditions become stricter and an agent begins to weigh counterparts' opinions with their attributes, such as match of expertise and power and status.

In the models in this section, the following effects of the psychosocial law become clear. First, unless the impact of non-experts' opinions is specifically cancelled, those

opinions are likely to determine an organization's action or inaction against potential problems in most cases. In both the symmetric and random world, the mean of agents' opinions moves toward the opinions of the non-experts. In other words, as occurred in the models in the previous sections on the feedback mechanism and potential embarrassment, non-experts are those who are given the most attention but give the least attention to others in the model in which agents behave following the psychosocial law. Under this condition, experts show indeterminacy on what to do against potential problems and their opinions continue to fluctuate. The fluctuation leads to indeterminacy at the organizational level. In short, the open-mindedness of experts allows non-experts to render an influence without initiating discussions about potential problems. When initiators select counterparts with higher power and status, the opinions of non-experts with higher power and status determine organizational-level choices if a non-expert is added to create the random world. When initiators select counterparts with the same power and status, the opinions of non-experts who do not have peers become the most influential in determining organizational-level choices. In this case, it is unimportant whether an added agent is an expert or a non-expert. These findings are true when an agent weighs counterparts' opinions simply by the order of encounter (Change Rule 1) or when an agent weighs those opinions with the order of encounter, counterparts' expertise, and their power and status (Change Rule 3).

Second, even under the same condition, if an added agent is an expert and initiators select counterparts with higher power and status, any agents with higher power and status determine organizational-level choices regardless of their expertise.

Third, under the condition in which an agent weighs counterparts' opinions only with their expertise (Change Rule 2), the opinions of experts determine organizational-level

choices, which is a new finding. Under the condition with Change Rule 2, the weights of non-experts' opinions become zero because they do not have expertise relevant to the potential problems. In the symmetric world and the random world to which an expert is added, experts' opinions determine organizational-level outcomes. In addition, there is no indeterminacy in experts' opinions at the organizational level after interactions. The indeterminacy disappears for three reasons. First, all of the experts initiate interactions in the models. Thus, their opinions converge to 0.0 as interactions continue due to the diminishing impact of counterparts' opinions for the change rule. Second, in the random world, the mean of experts' original opinions may not be 0.0 depending on the original opinion of an added expert. However, if the agent is an expert, it initiates interactions and its opinion changes following the diminishing term. Third, the mean of non-experts' opinions is 0.0 under the condition. Thus, the mean of all agents' opinions after interactions also becomes 0.0. As a result, the opinions of experts, rather than those of non-experts, determine organizational-level outcomes and the choices at the level are the mean of agents' original opinions. In these models, experts are those who are given the most attention and also give the most attention to others and their opinions determine whether an organization takes action against potential problems. When initiators select counterparts with higher power and status, the opinions of experts with higher power and status determine organizational-level choices. When they select counterparts with the same power and status, experts who do not have peers determine the choices.

One exception has emerged under the condition with Change Rule 2. Non-experts reclaim their power to determine organizational-level choices when the symmetric world becomes a random world by adding a non-expert. Under this condition, the mean of non-

experts' opinions, which does not change, shifts the mean of all agents' opinions away from that of their original opinions. The original opinion of the added non-expert determines the direction of the shift; if it is greater than 0.0, the direction is toward 1.0, but if it is less than 0.0, the direction is toward -1.0.

In short, it is difficult to predict who become members who are given the most attention but give the least attention to others in a simple manner. In some models, the agents are non-experts. In other models, the experts are those who are given the most attention and also give the most attention to others and their opinions determine organizational-level opinions on action or inaction against potential problems. Different conditions, such as how agents who initiate interactions weigh counterparts' opinions, lead to differences in who becomes influential in making a collective choice. The effects of the psychosocial law, including the attenuation effect of agents' attention, also introduce variations to how each agent weighs others' opinions and, thus, who will become influential.

In addition, the mechanisms behind organizational-level choices become clear with the above thought experiments, although the actual choices under each condition are not yet clear because they depend on the initial distributions of agents' attributes, i.e., opinions, match of expertise, and power and status. Running full-scale simulations is meaningful in studying the relationships between the initial distributions and the values of the actual choices.

In the next chapter, I summarize findings from the experiments in Chapters 4 and 5 and develop propositions about why organizational inaction emerges from members' interactions during ordinary and routine days.

CHAPTER 6

DISCUSSIONS AND CONCLUSION – THE MISSING PUZZLE PIECE REVISITED

This dissertation investigates the relationship between organizational decision-making and rare but salient events. It particularly addresses organizational conditions under which members collectively choose inaction, even when they recognize the problems that may lead to rare but salient events. These events have a substantial impact on people's lives. However, explaining the causal relationship in a simple, straightforward manner is difficult with existing organizational studies due to theoretical concerns and approaches peculiar to them, including the bias toward organizational successes. As a result, the simple, straightforward explanation is a missing puzzle piece in a landscape of otherwise rich organizational studies. To fill in this gap, this dissertation focuses on members' interactions during ordinary and routine days, a "gray zone" in which members notice potential problems but no clear and imminent threat to organizational performance has appeared yet. It also aims to explain why members' recognition of the problems does not lead to action at the organizational level.

For these purposes, this dissertation mainly draws on social psychological theories, and ABMs have been developed from them. In these models, agents, which are the operationalization of organization members, interact with each other following different sets of decision rules. The decision rules are the operationalization of organizational conditions, i.e., how favorable it is to speak up on and take action against the problems. By controlling

the sets of rules and the distributions of the values of agents' attributes – opinions, match of expertise, and power and status –, choices at the individual and organizational levels across different models are compared. Agents' individual choices are measured with changes in their individual opinions. In contrast, organizational-level choices are measured with changes in the mean of all agents' opinions, if they do not converge to one value. If they converge, the measurement is the value itself, which is equal to the mean of all agents' opinions under the convergence.

In this dissertation, only the minimalist models have been run on the simulation toolkit, whereas thought experiments are used for models that are more complicated. This distinction is due to a concern that running many complex ABMs at full scale may be counterproductive in understanding mechanisms behind outcomes of the models[20]. In addition, running such simulations will be a luxury if thought experiments can provide sufficient insights to answer the research questions. Despite this limitation, the ABS and experiments have led to interesting findings, especially about how organizational inaction emerges from members' interactions during ordinary and routine days. In the paragraphs that follow, I first explain those findings and develop propositions about organizational causes of rare but salient events. Then, I argue what these propositions imply for theories of organizational studies. Finally, I explain what further research is necessary.

Organizational Causes of Rare but Salient Events: Findings and Propositions

The outcomes of the experiments in Chapters 4 and 5 show two general trends. First, as organizational conditions become less favorable to speaking up and taking action, the

[20] Appendix C shows an example of the technical complexities that those models and the simulation may pose, which is the JavaScript code of one of the full-scale models. In running the steady-state simulation with random values, it is also necessary to run these codes multiple times (for all different models) under different conditions and to make statistical analyses relevant to the type of simulation. This requirement also makes the coding more complex with the necessity of a batch file and comparator files.

opinions of members who are given the most attention but give the least attention to others tend to determine organizational-level choices. In this chapter, members who hold these opinions are called "the detached" for the sake of convenience. Depending on the organizational conditions, the detached include non-experts, members with higher power and status than their colleagues, and those with more or fewer peers. Second, as the conditions become less favorable to speaking up and taking action, it is less likely that a consensus is reached at the organizational level. For example, if members pay more attention to the opinions of members with the same power and status, then an organizational-level consensus rarely emerges from discussions. These trends first depend on the designs of the ABMs and the controlled conditions created in the ABS. However, as long as the controlled conditions hold, the outcomes from these designs provide insights that are helpful in answering the questions of this dissertation.

First, it is necessary to explain three categories of "the detached". The first category consists of members without appropriate expertise. Their influence becomes conspicuous when they refrain from breaking silence because of their lack of expertise. There are exceptions to this influence, however. One example is when experts succumb to the effects of potential embarrassment of the bystander effect. In this case, the opinions of not only non-experts but also experts who do not initiate interactions influence organizational-level choices. The other example is when experts practically disregard non-experts' opinions due to the psychosocial law of social impact theory. One of the agents' decision rules based on the law dictates that experts should pay attention to counterparts' expertise but not their power and status. Under this condition, non-experts' opinions have an impact only if they are biased toward either action or inaction. These exceptions suggest that members without the

appropriate expertise become influential not simply because they lack the expertise. Rather, they become influential because they do not initiate interactions and change their opinions even if experts contact them. In short, they are detached.

The second category of the detached is members with higher power and status. Their opinions become influential when members who initiate interactions pay attention to power and status differences among their counterparts. Under this condition, members' expertise is not as important as their power and status. The influence of powerful and prestigious members depends on one-sidedness in members' efforts to ask for others' opinions. As their power and status increases, the number of their peers and superiors decreases. Thus, if members seek the opinions of these peers and superiors, those with higher power and status are likely to have fewer counterparts. In other words, as a member becomes more powerful and prestigious, more members ask for his/her opinions, but s/he is less likely to ask for others' opinions. As a result, the opinions of members with higher power and status do not change in relation to others' opinions. Then, the lack of changes results in an impact on organizational-level choices. Regardless of the willingness to discuss potential problems, members with higher power and status tend to become the detached.

The third category of the detached is members with more or fewer peers. Power and status structure is also important under the organizational condition in which members interact only with their peers. Under this condition, members with more peers become influential in most cases. In other cases, the psychosocial law causes the power of their attention to attenuate, and those with no peers claim the influence. In the former cases, members weigh the opinions of their counterparts based on their power and status. They give the same weight to peers' opinions as to their own; thus, the value of peers' opinions does not

fluctuate regardless of the order of their encounters. As discussions continue, the opinions of members with the same power and status cluster and the largest cluster forms around the opinions of the members with the most peers. In contrast, in the latter cases, members may weigh their peers' opinions less due to the attenuation of their attention. Thus, more peers indicate that they devalue each other's opinion more largely than otherwise. As a result, an individual without peers becomes the most influential member in determining organizational-level choices. These contradictory outcomes have one thing in common. The opinions of the detached are less likely to change than those of the involved, and the unchanging opinions determine the outcomes at the organizational level. Even in the former cases, members exclude subordinates and superiors from discussions by clustering with peers. This exclusion gives their opinions more power that determines organizational-level choices.

The detached share a few behaviors across the three categories. First, their behaviors seem to be smart. At the stage when they must decide whether it is acceptable to speak up in the organization, they choose not to do so because they are sensitive to organizational conditions. They pay attention to others' behavior, reflect on expertise of the self, and decide to remain quiet regardless of opinions about potential problems. Second, their behaviors seem to be stubborn once members who are less cautious at that stage break silence and begin to seek others' opinions. The detached do not change their opinions even if the less cautions contact them. It appears as if the detached never falter once they choose to remain silent and distant. In contrast, members who decide to break silence seem to be confident. They clear social-psychological obstacles posed by the bystander effect, social impact theory, or other group mentalities. In their eyes, others seem to support their interpretations of the potential problems. They also believe in their expertise to interpret the problems and find

solutions. However, these members are not so overconfident that they disregard others' opinions and organizational conditions. They are vigilant enough to pay attention to the power and status structure in the organization and others' expertise. This vigilance of members who initiate interactions allows the detached to influence them, regardless of whether the detached initiate interactions of their own. In other words, the models in Chapters 4 and 5 present different behaviors and decisions between the smart but stubborn and the confident but vigilant. In this regard, the question of this dissertation is variations in organizational decisions due to the difference.

Despite the explanations above, it is counterintuitive that the detached, not the involved, are influential in determining organizational action or inaction. However, the influence is understandable because the models represent members' interactions long before high-velocity situations emerge. The models and experiments in this dissertation describe members' decisions not in an emergency but in a "gray zone". Changes in individual members' opinions indicate the shift of their common understanding during ordinary and routine days. In this phase of rare but salient events, problems present only potential danger. In the "gray zone", members have freedom to remain quiet and/or favor inaction. This option distinguishes between the detached and the involved, and their difference determines choices, or the common understanding, at the organizational level. If the detached favor inaction in the face of potential problems, the opinion determines the common understanding. The common understanding represents how responsive members and the organization are to potential problems.

Proposition 1: As long as problems are still potential, the opinions of the detached members become more influential in determining organizational action or inaction than those of the involved members.

This dissertation also investigates the relationship between organizational conditions and organizational-level choices. The second trend in the outcomes in Chapters 4 and 5 is helpful in explaining the relationship. The experiments in Chapters 4 and 5 indicate that as organizational conditions become less favorable to speaking up and taking action, a consensus at the organizational level becomes less likely. In these experiments, sets of agents' decision rules are switched to control the patterns of members' interactions. Each of the sets represents different organizational conditions for speaking up and taking action. Thus, the outcomes of the experiments are members' choices under different organizational conditions.

For example, a set of agents' decision rules represents the organizational condition that is extremely open to speaking up and taking action. Under this condition, all members initiate interactions regardless of their expertise (Initiating Rule 1), interact with everyone regardless of the counterpart's power and status (Search Rule 1), and to make a decision, calculate the simple mean of all opinions (Change Rule 0A)[21]. Thus, the organizational-level choice under this condition is the simple mean of members' original opinions. It appears as if interactions neutralize extreme opinions whether they favor action or inaction. As a result, members choose the existing common understanding as the organizational-level choice while they discuss potential problems. In other words, in an organization in which speaking up and taking action are acceptable, shared beliefs of members that already exist in the organization determine organizational action or inaction. In an organization with this open atmosphere and culture, it is highly likely that the existing common understanding dictates action to solve

[21] This model is ABM 1 of the minimalist model in Chapter 4.

potential problems. However, a variance in the shared beliefs may exist across organizations under the same condition, and examining the possibility is beyond the scope of this dissertation. Still, it is possible to make the following proposition:

Proposition 2a: When an organization has an atmosphere and culture open to speaking up and taking action, organizational decisions on what to do about potential problems are likely to be the same as existing beliefs that most of the members share before they begin to discuss the problems.

The condition becomes unfavorable to speaking up and taking action as members begin to hesitate to speak up due to their lack of appropriate expertise (Initiating Rule 2) and select counterparts based on power and status differences (Search Rules 2 to 4). The condition also becomes unfavorable as members begin to weigh the counterparts' opinions based on their expertise and power and status (Change Rules 0B to 0D) and based on the order of encounters (Change Rules 1 to 3). In the experiments in Chapters 4 and 5, a consensus becomes less likely as organizational conditions become less favorable to speaking up and taking action. Even if opinions of members who initiate discussions are on the verge of convergence, the opinions of the detached prevent a consensus. The lack of the consensus seems to be reasonable because members are in a "gray zone". Without clearly negative events that trigger changes in opinions and attitudes, members are not likely to be driven to reach a consensus on what to do, especially when organizational conditions do not allow them to freely discuss problems. Although the confident but vigilant members discuss their concerns, the smart but stubborn tend to remain quiet. Despite the silence, the opinions of the detached affect organizational-level choices.

Proposition 2b: As organizational conditions become less favorable to speaking up and taking action, it becomes less likely that members reach a consensus at the organizational level on what to do about potential problems.

The three propositions above lead to a simple and general model of organizational decision-making in a "gray zone". Figure 6.1 on the next page shows the model. In the figure, squares and arrows indicate how members' opinions change from existing common understandings to organizational-level choices. Ovals indicate the determining factors described in the propositions. Dashed arrows indicate the effects of organizational conditions or opinions that favor speaking up and taking action, whereas doted arrows indicate the conditions and opinions that do not favor speaking up and taking action. At the beginning, there is a common understanding among members, which has developed through members' socialization, adaptation, and other learning. Then, after members recognize potential problems and some of them begin discussions, organizational conditions determine outcomes at the organizational level. If the conditions are favorable to speaking up, or sharing concerns about potential problems, a consensus is likely to emerge. If not, a consensus is less likely at the organizational level. In either case, the opinions of the detached, i.e., those of the smart but stubborn, determine whether an organization takes action to solve potential problems. If the detached favor action, the organizational choice also tends to be taking action. If not, the choice tends to be inaction. However, if members cannot reach a consensus at the organizational level, the choice is only a matter of tendency toward either action or inaction depending on the opinions of the detached.

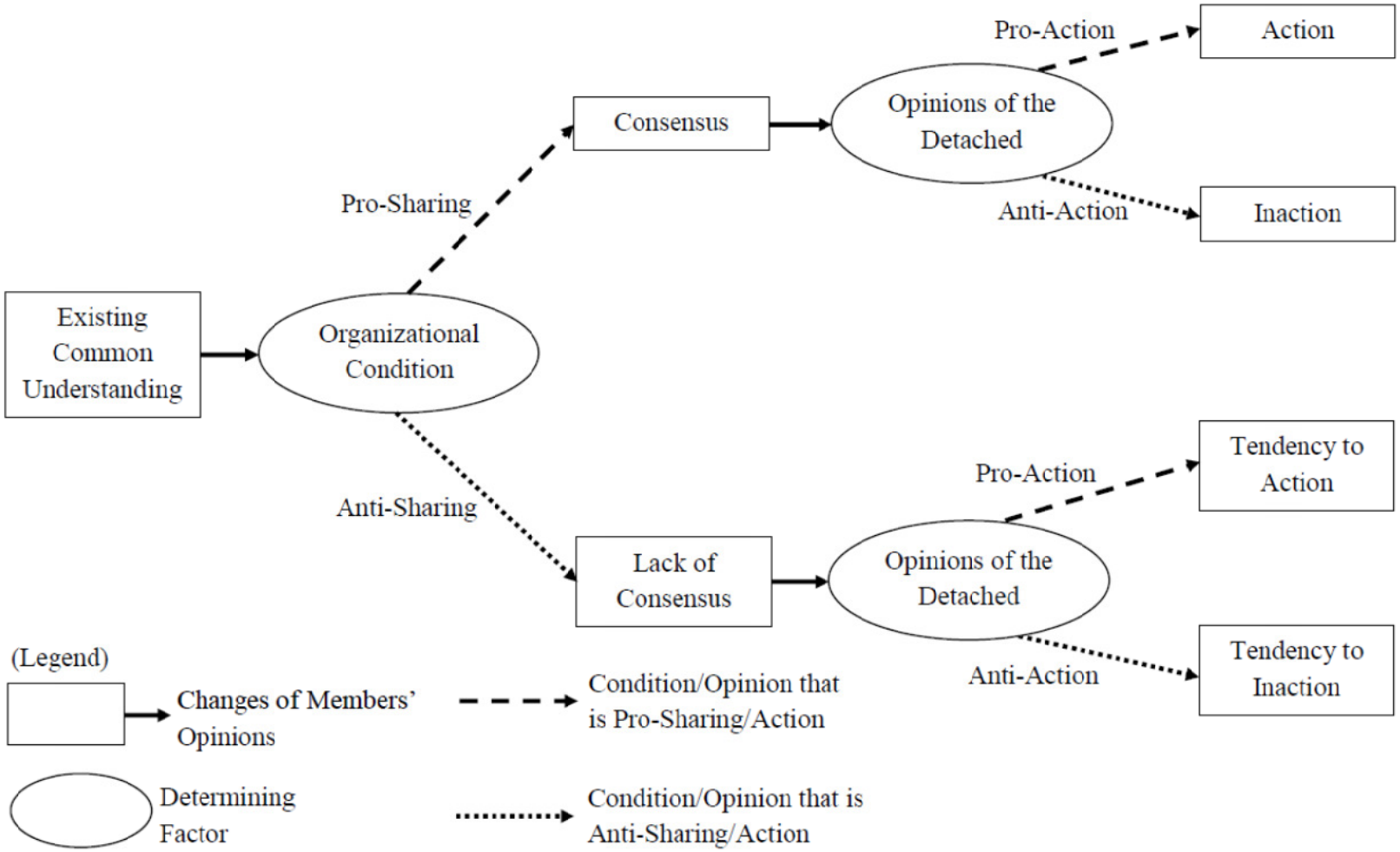

Figure 6.1. A Model of Organizational Decisions in a Gray Zone

The propositions and the model in Figure 6.1 reveal that paying attention only to discussions by the involved is insufficient for an observer or a manager to understand members' collective decisions. It is necessary to uncover the unspoken opinions of the detached members. Otherwise, these opinions may obstruct organizational action when members are on the verge of high-velocity situations. These opinions are silent yet enduring and powerful in a "gray zone"; thus, they may hamper efforts of the involved to solve potential problems prior to serious incidents. This is probably why the recognized security holes in airport passenger screening had remained until 9/11. Those who were concerned repeatedly mentioned the problem, for example, analysts in the Office of Inspector General of the Department of Transportation and the Government Accounting Office. However, the organizational-level choice in the FAA and airline companies seemed to do nothing about the potential problem even though it was never explicitly spoken.

Proposition 3: When the opinions of the detached members favor inaction more than action against potential problems, rare but salient events are more likely to emerge from organizational inaction during ordinary and routine days.

The findings in this dissertation have implications for existing organizational studies concerning rare but salient events, such as theories on organizational learning, high-reliability organizations, and normal accidents. The next section describes these implications.

Implications of the Puzzle Piece for Organizational Studies

Chapters 1 and 2 of this dissertation discuss that studies on organizational causes of rare but salient events are missing in the rich landscape of existing organizational studies. Now that the missing piece or, at least, part of it has been found, the question is what it

implies for the existing studies. First, I explain what it suggests about theories on organizational learning.

In Chapter 2, I argued that theories on organizational learning do not fully explain organizational causes of rare but salient events because these theories concern organizational responses to the events. Organizational learning concerns members' behavior in the phase after high-velocity situations begin to co-evolve with rare but salient events, whereas the causes develop long before the phase. The findings of this dissertation support this argument. While an organization is still in a "gray zone", no clear threat to members' aspiration levels or organizational performance has emerged yet. In the situation, some members may prefer inaction to action, and if they are one of the detached, their opinions shift organizational-level choices toward inaction. No reason exists to assume that all members are driven to change their routines.

The influence of the detached has three implications for theories on organizational learning. First, it resonates with a lingering question of what organizational learning is (e.g., Cook and Yanow 1996; Levitt and March 1988; March 1991; Weick 1996; Weick and Westley 1996). Individual members may learn from feedback on their decisions, but exactly who among individual members is learning when organizational learning occurs? Is an organization learning when the management leads changes even if some of the members do not relate to the movement? Is an organization learning when lower-tier members proactively change their behaviors even if the management is not informed or indifferent to the changes? It seems to be unimportant in this subfield of organizational studies to question exactly who among members supports and complies with changes when *an organization* is considered to change.

This ambiguity in the actors of organizational learning may lead to the confusion about the phases of rare but salient events that I explained in Chapter 2. If the question concerning who learns is not important, the question concerning who does not want changes is also unimportant. The lack of concern may lead to the lack of interest in the detached members. As a result, *an organization* is assumed to intentionally learn and prevent rare but salient events while it is still in a "gray zone". For example, a top-down change by the management may be equated with a case of *organizational* learning even if members who are affected by the change have different opinions and even attempt to bypass it as much as possible.

Second, the ambiguity and the lack of concern result in the difficulty in explaining why similar organizational accidents are repeated, such as the accident of the space shuttle Columbia seventeen years after that of the Challenger. Organizational non-learning and unlearning provide insights into the recurrence of accidents. However, the findings of this dissertation suggest that it is necessary to examine how the opinions of the detached evolve during the period between two similar accidents.

Third, studies on organizational learning synergize with those on organizational routines as previously explained. Thus, the implications for the former are applicable to the latter. In Chapter 3, I argued that with the models and simulation in this dissertation, it is possible to answer a question about organizational routines. Can they change without "exogenous shocks"? The findings of this dissertation suggest that the change depends on organizational conditions and the opinions of the detached members in a "gray zone". The model in Figure 6.1 indicates that if the conditions are favorable to speaking up and taking action and if the detached favor action, routines can change without events that negatively

affect organizational performance. In contrast, if the detached favor inaction, changes are less likely without such events. This hypothesis is very general because it is based not on case studies about specific organizations but on a weak model of organizational decision-making in a "gray zone". If the model is truly generalizable, similar relationships between the opinions of the detached and changes in organizational routines will be found across cases.

With respect to theories on HROs, the findings of this dissertation help to explain why even HROs cause large-scale accidents. The difficulty of the theories, as explained in Chapter 2, is that they concern organizational preparedness for, not the causes of, rare but salient events. As a result, those who draw on the theories to explain the causes are left to wonder whether the lack of preparedness leads to the events. However, an HRO is supposed to prepare for preventing and controlling high-velocity situations. The question is not whether an organization is one of the HROs but when prepared routines of HROs serve to prevent rare but salient events. The findings of this dissertation suggest that the routines are successful in preventing the events when the detached prefer action against potential problems. To prevent rare but salient events, members of HROs must take action in a "gray zone". The possibility depends on the opinions of the detached. Regardless of discussions among other members, if the detached prefer inaction, their behavior may drag organizational actions to solve potential problems. In contrast, if the detached prefer action, the prepared routines of HROs are more likely to contribute to preventing rare but salient events.

A rare but salient event in one of the HROs, the U.S. Navy, highlights this point. In 2008, the USS George Washington experienced an on-board fire that injured approximately forty sailors and seriously damaged the aircraft carrier after long hours of fire-fighting. The investigation (Drennan 2008) illustrates how the inaction of the detached led to the disaster

despite the actions of the involved. For example, some of the crew stored oil containers in a non-hazmat space "below the deck plates in the auxiliary boiler room" (Drennan 2008:11). Others stored combustible materials such as clothing and documents in a space not designated for the purpose. Still others smoked in unauthorized areas and hid their cigarette butts into the inlet plenum from which exhausts entered the boiler room. Even after the inappropriate storage of these containers were found in a walk-through inspection, the sailors handed only some of the containers to the Hazmat Division because it was less laborious to keep them at hand than to visit the Division and go through the hand-out process. The investigation after the fire also found that the crew stored other hazardous materials, such as paint thinner, in the room. A probable reason of the hours-long fire-fighting and many casualties is that the source of fire was hardly identifiable because the storage and smoking had occurred where they should not and the combustible materials were not supposed to be in the room on the day.

Even in this disastrous case, part of the HRO's routines was successfully implemented. First, the improper storage was found in an inspection. After that, a few other officers volunteered to perform other rounds of inspections. They walked through the room again, could not find the containers hidden in the space, and reported that the problem had been solved. Second, there were series of training for hazmat handling and damage control although the investigation found them insufficiently done. Finally, after the fire started, the crew mobilized the prepared routines to prevent the high-velocity situation from escalating, such as fire-fighting and search and rescue of the missing. However, the violations of the storage and smoking policies at the beginning, and even worse, the continued storage of hazardous materials after the inspections suggest that at least some of the sailors continued to

commit risky behaviors even after the crew shared their knowledge of potential problems. Their inaction eventually led to the fire despite actions by members who attempted to solve the potential problems.

This case depicts how the opinions and behavior of the detached invalidate the preparedness of HROs in a "gray zone". Once a high-velocity situation emerges, the preparedness pays. However, before members face the situation, they have a margin for inaction, and if the detached favor the opinion and behavior, a high-velocity situation emerges even from HROs and result in a rare but salient event.

The findings of this dissertation are also helpful in filling the gap in theories on normal accidents. The theories explain the causes of rare but salient events that develop in a "gray zone". The problem, as explained in Chapter 2, is that the explanation is more institutional than organizational. According to the theories, social and economic demands determine what organizations do even if their members recognize potential problems, such as the design and management of risky systems. However, what occurs inside an organization is unclear, such as members' decisions about continuing to select and use the risky systems. It is also unclear why large-scale accidents are statistically rare except for luck. The influence of the detached members may provide the organizational-level explanations. In an organization in which the opinions of the detached favor action, some changes may occur to the decisions about selecting and using the risky systems. Otherwise, no action may be taken, and the public's safety relies on chance.

Future Research about Organizational Causes of Rare but Salient Events

One point is clear from the findings of this dissertation and their implications for existing organizational studies. Understanding the opinions of the detached members is

necessary to explain organizational action or inaction before members face high-velocity situations. This necessity seems to be daunting because it appears as if answers lie in, for example, thoughts of non-respondents in a survey whose response rate is already satisfactory. However, the detached is not limited to members who are smart enough to remain quiet. The category of members also includes those who are confident enough to speak up but whose power and status does not match that of their colleagues. In terms of organizational causes of rare but salient events, those members are paradoxically weak links, but following the links and examining their opinions will contribute to understanding organizational decision-making that may lead to rare but salient events.

This dissertation has used strictly controlled experiments and thought experiments to answer the research questions on the organizational causes of rare but salient events. This approach is useful in explicating the mechanisms through which collective choices emerge from members' interactions. To verify the findings of this dissertation and to test the propositions in this chapter, running full-scale simulations with randomized values will be helpful. In the process, it will also become clear how probable a certain organizational choice is, how likely it is that a category of the detached, such as non-experts, members with higher power and status, or members with more or fewer peers, influences the choice, and how quickly members make the choice with a feedback mechanism.

In running the full-scale, randomized simulations, it is also necessary to ensure that different outcomes occur because of different organizational conditions rather than other sources of in-model and across-model variances. However, too much control of variances causes problems in terms of independence among samples, i.e., the outcomes from multiple runs of an ABM or data points of a run of an ABM. Thus, a balance is required to achieve

independence and identicalness among samples and variance reduction at the same time. This balance is important especially because first, the ABMs for the research are unlikely to be based on empirical data and second, the ABS is a computer program. For example, controlling outliers is necessary while maintaining independence among samples. Then, it is necessary to ensure that simulation outcomes concern the same phenomena even when each run of the model is independent. The first question concerns the issue of independent and identical replications of ABMs, whereas the second one concerns the number of runs and the length of a run of the ABMs.

To maintain independence and identicalness across samples or outputs of multiple runs of an ABM at the same time, three settings are necessary (Goldsman 2010; Kelton 1997; Law 2006a; Law 2006b; Nakayama 2008). First, each run must be started under initialized conditions for agents' attributes and topology. For example, agents must reside in an initialized, different topology in each run of an ABM. The randomness in topology is necessary for independence among outcomes of each run. Because locations and connections among agents are initialized at the start of each run of a model, each of the runs is about an independent sample organization under the same condition, i.e., the same set of agents' decision rules. In this manner, outcomes of an ABM inform about different sample organizations in which members interact in the same patterns.

Second, to generate the values of the agents' attributes in the initial conditions, the random number generator must have the same seeds. With these seeds, the random number generator becomes a pseudo random number generator, which behaves as if it were rolling a die. When one rolls a die, the outcomes are independent (random), but the numbers generated are in a certain sequence from 1 to 6. In addition, the distributions of each number will

follow a certain probability distribution, that is, it becomes uniform if the die is rolled hundreds or thousands times. However, in a limited number of trials, i.e., as a sample, the value that will show up next is not predictable. In other words, the seeds that satisfy these conditions must be chosen. Generating random values of agents' attributes in this way helps to prevent extreme outliers in the initial conditions and to maintain identicalness of outcomes.

Third, each model must be run multiple times with the same sets of decision rules. In other words, samples must be collected under an identical organizational condition whereas these conditions must differ across models. The different sets of agents' decision rules represent different conditions for members' interactions; thus, they constitute different ABMs. By repeatedly running an ABM with a certain set of the decision rules, multiple samples are generated under one identical organizational condition. In contrast, by running multiple ABMs with different sets of decision rules, samples about organizations under different conditions are generated.

With these settings, in-model and across-model variances are reduced to those caused by randomness in their topology, random values of agents' attributes, and different sets of their decision rules at the start of each run, all of which are controlled to an extent. As a result, outcomes of each run of a model are likely to be identical. In addition, the outcomes become independent because the attributes and topology are initialized at the start of each run. By changing the combinations of agents' decision rules across the ABMs, it is possible to compare outcomes from different interaction patterns of members, which have independent samples per pattern.

The next question is how many times an ABM must be run and how long each run must be. In this regard, there are two choices: terminating simulation and infinite-time

simulation. A terminating simulation is an ABS whose ticks are predetermined whereas an infinite-time simulation does not have predetermined ticks. The latter is also called a steady-state simulation because the steady state assumes that ticks are infinite, whereas outcomes do not usually reach the steady state in terminating simulations[22] (Alexopoulos and Kim 2002; Goldsman 2010; Kelton 1997; Law 2006a; Law 2006b; Nakayama 2008). In addition, ticks sufficient to reach the steady state are difficult to predict because the length depends on models. Therefore, the necessary number of ticks is unknown before observing behaviors of a model (Alexopoulos and Kim 2002; Goldsman 2010; Kelton 1997; Law 2006a; Law 2006b; Nakayama 2008). In Chapter 4, terminating simulations were used because the purpose of the chapter was to clarify the mechanisms behind organizational-level choices by controlling conditions of the minimalist models to unrealistic degrees. In addition, the simulations were run only once. However, in future research, running the ABMs for infinite time and multiple times will be necessary to generate as many random samples as possible and to discuss the probabilities of a certain organizational decision.

Conclusion

In today's society, organizational roles in rare but salient events are significant because organizations appear in all aspects of human life. Thus, rare but salient events are

[22] Methods of statistical analysis also differ between terminating simulations and infinite-time simulations. For the former, finding the mean and showing the confidence interval of the variance are the basic methods. For the latter, finding the mean becomes more complicated, which demands different methods such as batch mean, standardized time series, spectrum analysis, and so on. It is also necessary to remove data in the stochastic phase from outcomes. For details, see Alexopoulos, Christos, and Seong-Hee Kim. 2002. "Output Data Analysis for Simulations." Pp. 85-96 in *Winter Simulation Conference*, edited by E. Yücesan, C.-H. Chen, J. L. Snowdon, and J. M. Charnes: IEEE, Goldsman, Dave. 2010. "Simulation Output Analysis." Atlanta, GA: School of ISyE, Georgia Tech, Kelton, David W. 1997. "Statistical Analysis of Simulation Output." Pp. 23-30 in *Winter Simulation Conference*, edited by A. Andoraclóttir, K. J. Healy, D. H. Withers, and B. L. Nelson: IEEE, Law, Averill M. 2006a. *Simulation Modeling and Analysis*. New York, NY: McGraw-Hill, —. 2006b. "Statistical Analysis of the Output Data from Terminating Simulations." *Naval Research Logistics Quarterly* 27:131-143, Nakayama, Marvin K. 2008. "Statistical Analysis of Simulation Output." Pp. 62-72 in *Winter Simulation Conference*, edited by S. J. Mason, R. R. Hill, L. Mönch, O. Rose, T. Jefferson, and J. W. Fowler: IEEE.

issues of *organizational* decision-making rather than individual risk taking by members or personal fear among the public. It is worthwhile to question why organizations do not take action in advance, even when members recognize potential problems. It is especially important to examine how collective decisions of inaction emerge while members are collaborating in ordinary and routine days. It is also important to explain the emergence beyond a level of analysis, such as individual psychology, a group or unit in an organization, or an organization that is an ambiguous entity in terms of individual and collective cognition and decision-making. Studying rare but salient events with large-scale data is difficult because of their statistical infrequency and the uncertainty accompanying the infrequency. It is also difficult to generalize findings from case studies on rare but salient events and apply them to other cases. In an effort to solve these problems, this dissertation has shown that an ABS and a multi-level approach are helpful in explaining the mechanisms of and generating hypotheses on organizational decision-making that may lead to rare but salient events. The ABS also seems to be helpful in generating sufficient sizes of random samples with the steady-state simulation and multiple runs of ABMs.

In addition, this dissertation has revealed the necessity of studying the opinions of members who do not speak up and/or who do not have peers and superiors in the power and status structure. This need is different from managerial necessity to prevent organizational silence. Rather, it directs attention to the possibility that beliefs, understandings, opinions, and behaviors of the detached members may drag an organization into inaction despite other members' efforts to solve potential problems. In a "gray zone", situations that are not of high velocity yet allow the opinions of the detached to remain below the radar because without a clear threat to organizational performance, no urgent reason to mobilize the detached for

changes exists. However, the lack of the reason does not indicate that the opinions of the detached do not have an impact on common understandings among members and organizational-level choices. Indeed, the influence of the detached is significant. The findings of this dissertation suggest that organizational inaction in a "gray zone" depends on the unheard, forgotten opinions of the detached, which may eventually cause rare but salient events and damages to the public's life and safety.

Appendix A

Agents' Attributes, Decision Rules, and Outcomes of the Minimalist Models

ABM	Agents' Attributes {Member 1, Member 2, Member 3}			Agents' Decision Rules			Outcomes
	Opinion	Expertise	Power and Status	Initiating Rule	Search Rule	Change Rule	
1	{0.5, 0.0. 0.5}	N/A	N/A	1	1	0A	0.33...
2		{1, 0, 0}	N/A	2	1	0B	No Consensus
3		{0, 1, 0}	N/A	2	1	0B	0.50
4		{1, 1, 0}	N/A	2	1	0B	0.50
5		{1, 0, 1}	N/A	2	1	0B	0.00
6		N/A	{1, 1, 2}	1	2	0C	0.50
7		N/A	{1, 2, 2}	1	2	0C	0.25
8		N/A	{1, 2, 1}	1	2	0C	0.00
9		N/A	{2, 1, 2}	1	2	0C	0.50
10		N/A	{1, 1, 2}	1	3	0C	0.50
11		N/A	{1, 2, 2}	1	3	0C	No Consensus
12		N/A	{1, 2, 1}	1	3	0C	0.00
13		N/A	{2, 1, 2}	1	3	0C	0.50
14		N/A	{1, 1, 2}	1	4	0C	Majority Choice of 0.25
15		N/A	{1, 2, 2}	1	4	0C	Majority Choice of 0.25
16		N/A	{1, 2, 1}	1	4	0C	Majority Choice of 0.50 (No Changes from Initial Opinions)
17		N/A	{2, 1, 2}	1	4	0C	Majority Choice of 0.50 (No Changes from Initial Opinions)
18		{0, 1, 0}	{1, 2, 2}	2	2	0D	0.50
19		{1, 1, 0}	{1, 2, 2}	2	2	0D	0.50
20		{1, 0, 1}	{1, 2, 2}	2	2	0D	0.00
21		{0, 1, 0}	{1, 2, 2}	2	4	0D	0.50
22		{1, 1, 0}	{1, 2, 2}	2	4	0D	0.50
23		{1, 0, 1}	{1, 2, 2}	2	4	0D	Majority Choice of 0.00
24		{1, 0, 0}	{2, 1, 2}	2	4	0D	Majority Choice of 0.50 (No Changes from Initial Opinions)
25		{1, 1, 0}	{2, 1, 2}	2	4	0D	Majority Choice of 0.50 (No Changes from Initial Opinions)
26		{1, 0, 1}	{2, 1, 2}	2	4	0D	Majority Choice of 0.50 (No Changes from Initial Opinions)

Table 1. Models of the Controlled Experiments

Decision Rules		Corresponding Figures
Initiating Rule 1	An agent initiates interactions with other agents regardless of the values of its attributes and organizational conditions	4.1, 4.5, 4.6, 4.7, 4.8
Initiating Rule 2	An agent initiates interactions with other agents if the value of its own match of expertise is 1	4.2, 4.3, 4.4, 4.9, 4.10, 4.11
Search Rule 1	An agent chooses any other agents as its counterparts regardless of the values of their power and status	4.1, 4.2, 4.3, 4.4
Search Rule 2	An agent chooses other agents as its counterparts if they have the same or higher values of power and status	4.6, 4.11
Search Rule 3	An agent chooses other agents as its counterparts if they have higher values of power and status	4.5
Search Rule 4	An agent chooses other agents as its counterparts if they have the same value of power and status	4.7, 4.8, 4.9, 4.10
Change Rule 0A	$AO_i = \left(O_i + \sum_{ci=1}^{CI} O_{ci}\right)/(CI + 1)$, where AO_i is an agent's opinion value after a round of interactions, O_i is an agent's opinion value before a round of interactions, O_{ci} is a counterpart's opinion value, and CI is the number of counterparts	4.1
Change Rule 0B	$AO_i = \left(O_i * IO_i + \sum_{ci=1}^{CI}(O_{ci} * IO_{ci})\right)/\left(CI * \sum_{ci=1}^{CI} IO_{ci} + 1 * IO_i\right)$, where IO_i is the impact of an agent's opinion value, IO_{ci} is the impact of a counterpart's opinion value, $E = 1 \Leftrightarrow IO = 2$ whereas $E = 0 \Leftrightarrow IO = 1$, and E is agents' match of expertise	4.2, 4.3, 4.4
Change Rule 0C	$AO_i = \left(O_i * IO_i + \sum_{ci=1}^{CI}(O_{ci} * IO_{ci})\right)/\left(CI * \sum_{ci=1}^{CI} IO_{ci} + 1 * IO_i\right)$, where $PS_{ci} > PS_i \Leftrightarrow IO_{ci} = 2, PS_{ci} = PS_i \Leftrightarrow IO_{ci} = 1, PS_{ci} < PS_i \Leftrightarrow IO_{ci} = 0.5$, PS_{ci} is a counterpart's power and status, and PS_i is an agent's power and status	4.5, 4.6, 4.7, 4.8
Change Rule 0D	$AO_i = \left(O_i * IO_i + \sum_{ci=1}^{CI}(O_{ci} * IO_{ci})\right)/\left(CI * \sum_{ci=1}^{CI} IO_{ci} + 1 * IO_i\right)$, where $IO_i = \{2, 1\}$ and $IO_{ci} = \{4, 3, 2, 2.5, 1.5\}$	4.9, 4.10, 4.11

Table 2. Details of Agents' Decision Rules for the Controlled Experiments

Appendix B

Agents' Attributes and Decision Rules of the Thought Experiments

ABM	Added Factors	World	Agents' Attributes			Agents' Decision Rules		
			Opinion	Expertise	Power and Status	Initiating Rule	Search Rule	Change Rule
27	Feedback Mechanism	Symmetric	$O \sim U(-1, 1)$	$B(1, 0.5)$	N/A	2	1	0B
28		Random	Biased	Biased	N/A	2	1	0B
29					Added	2	1	0D
30					Added	2	3	0D
31					Added	2	2	0D
32					Added	2	4	0D
33	Potential Embarrassment	Symmetric	$O \sim U(-1, 1)$	$B(1, 0.5)$	N/A	3A	1	0B
34					N/A	3B	1	0B
35					N/A	3C	1	0B
36		Random	Biased	Biased	N/A	3A	1	0B
37					N/A	3B	1	0B
38					N/A	3C	1	0B
39					Added	3A	3	0D
40					Added	3B	3	0D
41					Added	3C	3	0D
42					Added	3A	4	0D
43					Added	3B	4	0D
44					Added	3C	4	0D
45	Psychosocial Law	Not Defined	Not Defined	Not Defined	N/A	1	1	1
46					N/A	1	1	2
47					N/A	1	1	3
48		Symmetric	$O \sim U(-1, 1)$	$B(1, 0.5)$	N/A	2	1	1
49					N/A	2	1	2
50					N/A	2	1	3
51		Random	Biased	Biased	N/A	2	1	1
52					N/A	2	1	2
53					N/A	2	1	3
54					Added	2	3	1
55					Added	2	4	1
56					Added	2	3	2
57					Added	2	4	2
58					Added	2	3	3
59					Added	2	4	3

Table 3. Models of the Thought Experiments

Decision Rules	
Initiating Rule 1	An agent initiates interactions with other agents regardless of the values of its attributes and organizational conditions
Initiating Rule 2	An agent initiates interactions with other agents if the value of its own match of expertise is 1
Initiating Rule 3A	An agent initiates interactions if at least one confidant has an opinion equal to or larger than its own opinion
Initiating Rule 3B	An agent initiates interactions if at least two confidants have opinions equal to or larger than its own opinion
Initiating Rule 3C	An agent initiates interactions if at least three confidants have opinions equal to or larger than its own opinion
Search Rule 1	An agent chooses any other agents as its counterparts regardless of the values of their power and status
Search Rule 2	An agent chooses other agents as its counterparts if they have the same or higher values of power and status
Search Rule 3	An agent chooses other agents as its counterparts if they have higher values of power and status
Search Rule 4	An agent chooses other agents as its counterparts if they have the same value of power and status
Change Rule 0B	$AO_i = \left(O_i * IO_i + \sum_{ci=1}^{CI}(O_{ci} * IO_{ci})\right)/\left(CI * \sum_{ci=1}^{CI} IO_{ci} + 1 * IO_i\right)$, where AO_i is an agent's opinion value after a round of interactions, O_i is an agent's opinion value before a round of interactions, IO_i is the impact of an agent's opinion value, O_{ci} is a counterpart's opinion value, IO_{ci} is the impact of a counterpart's opinion value, CI is the number of counterparts, $E = 1 \Leftrightarrow IO = 2$ whereas $E = 0 \Leftrightarrow IO = 1$, and E is agents' match of expertise
Change Rule 0D	$AO_i = \left(O_i * IO_i + \sum_{ci=1}^{CI}(O_{ci} * IO_{ci})\right)/\left(CI * \sum_{ci=1}^{CI} IO_{ci} + 1 * IO_i\right)$, where $IO_i = \{2, 1\}$ and $IO_{ci} = \{4, 3, 2, 2.5, 1.5\}$
Change Rule 1	$AO_i = \left(O_i * IO_i + \sum_{ci=1}^{CI} IO_{ci}\right)/\left(IO_i + \sum_{ci=1}^{CI} I_{ci}\right)$, where $IO_i = 1$, $IO_{ci} = O_{ci} * [(CI - j_{ci} + 1) * 1/CI] * exp\hat{}(-\zeta * j_{ci})$, and $I_{ci} = [(CI - j_{ci} + 1) * 1/CI] * exp\hat{}(-\zeta * j_{ci})$.
Change Rule 2	$AO_i = \left(O_i * IO_i + \sum_{ci=1}^{CI} IO_{ci}\right)/\left(IO_i + \sum_{ci=1}^{CI} I_{ci}\right)$, where $IO_i = 1$, $IO_{ci} = O_{ci} * [E_{ci} * (CI - j_{ci} + 1) * 1/CI] * exp\hat{}(-\zeta * j_{ci})$, and $I_{ci} = [E_{ci} * (CI - j_{ci} + 1) * 1/CI] * exp\hat{}(-\zeta * j_{ci})$
Change Rule 3	$AO_i = \left(O_i * IO_i + \sum_{ci=1}^{CI} IO_{ci}\right)/\left(IO_i + \sum_{ci=1}^{CI} I_{ci}\right)$, where $IO_i = 1$, $IO_{ci} = O_{ci} * [(E_{ci} + PS_{ci}/50) * (CI - j_{ci} + 1) * 1/CI] * exp\hat{}(-\zeta * j_{ci})$, and $I_{ci} = [(E_{ci} + PS_{ci}/50) * (CI - j_{ci} + 1) * 1/CI] * exp\hat{}(-\zeta * j_{ci})$

Table 4. Details of Agents' Decision Rules for the Thought Experiments

Appendix C
An Example of the JavaScript Code for a Full-Scale Model

Note: Although this file was automatically created by Repast Simphony Integrated Development Environment, the code that defined agents' behaviors was manually written by the author of this dissertation, Junko Shimazoe. Any mistakes in that part of coding are the author's responsibility.

```
/**
 *
 * This file was automatically generated by the Repast Simphony Agent
Editor.
 * Please see http://repast.sourceforge.net/ for details.
 *
 */

/**
 *
 * Set the package name.
 *
 */
package dissertation0

/**
 *
 * Import the needed packages.
 *
 */
import java.io.*
import java.math.*
import java.util.*
import javax.measure.unit.*
import org.jscience.mathematics.number.*
import org.jscience.mathematics.vector.*
import org.jscience.physics.amount.*
import repast.simphony.adaptation.neural.*
import repast.simphony.adaptation.regression.*
import repast.simphony.context.*
import repast.simphony.context.space.continuous.*
import repast.simphony.context.space.gis.*
import repast.simphony.context.space.graph.*
import repast.simphony.context.space.grid.*
import repast.simphony.engine.environment.*
import repast.simphony.engine.schedule.*
import repast.simphony.engine.watcher.*
import repast.simphony.groovy.math.*
import repast.simphony.integration.*
import repast.simphony.matlab.link.*
import repast.simphony.query.*
import repast.simphony.query.space.continuous.*
import repast.simphony.query.space.gis.*
import repast.simphony.query.space.graph.*
import repast.simphony.query.space.grid.*
import repast.simphony.query.space.projection.*
```

```
import repast.simphony.parameter.*
import repast.simphony.random.*
import repast.simphony.space.continuous.*
import repast.simphony.space.gis.*
import repast.simphony.space.graph.*
import repast.simphony.space.grid.*
import repast.simphony.space.projection.*
import repast.simphony.ui.probe.*
import repast.simphony.util.*
import simphony.util.messages.*
import static java.lang.Math.*
import static repast.simphony.essentials.RepastEssentials.*

/**
 *
 * This is an agent.
 *
 */
public class Member  {

    /**
     *
     * This is an agent property.
     * @field opinion
     *
     */
    @Parameter (displayName = "opinion", usageName = "opinion")
    public double getOpinion() {
        return opinion
    }
    public void setOpinion(double newValue) {
        opinion = newValue
    }
    public double opinion = 0

    /**
     *
     * This is an agent property.
     * @field exptMatch
     *
     */
    @Parameter (displayName = "exptMatch", usageName = "exptMatch")
    public int getExptMatch() {
        return exptMatch
    }
    public void setExptMatch(int newValue) {
        exptMatch = newValue
    }
    public int exptMatch = 0

    /**
     *
     * This is an agent property.
     * @field infPwrStat
     *
     */
    @Parameter (displayName = "infPwrStat", usageName = "infPwrStat")
```

```
    public double getInfPwrStat() {
        return infPwrStat
    }
    public void setInfPwrStat(double newValue) {
        infPwrStat = newValue
    }
    public double infPwrStat = 0

    /**
     *
     * This is an agent property.
     * @field formPwrStat
     *
     */
    @Parameter (displayName = "formPwrStat", usageName = "formPwrStat")
    public double getFormPwrStat() {
        return formPwrStat
    }
    public void setFormPwrStat(double newValue) {
        formPwrStat = newValue
    }
    public double formPwrStat = 0

    /**
     *
     * This is an agent property.
     * @field pwrStat
     *
     */
    @Parameter (displayName = "pwrStat", usageName = "pwrStat")
    public int getPwrStat() {
        return pwrStat
    }
    public void setPwrStat(int newValue) {
        pwrStat = newValue
    }
    public int pwrStat = 0

    /**
     *
     * This is an agent property.
     * @field potEmbCounter1
     *
     */
    @Parameter (displayName = "potEmbCounter1", usageName =
"potEmbCounter1")
    public int getPotEmbCounter1() {
        return potEmbCounter1
    }
    public void setPotEmbCounter1(int newValue) {
        potEmbCounter1 = newValue
    }
    public int potEmbCounter1 = 0

    /**
     *
     * This is an agent property.
```

```
     * @field potEmbCounter2
     *
     */
    @Parameter (displayName = "potEmbCounter2", usageName =
"potEmbCounter2")
    public int getPotEmbCounter2() {
        return potEmbCounter2
    }
    public void setPotEmbCounter2(int newValue) {
        potEmbCounter2 = newValue
    }
    public int potEmbCounter2 = 0

    /**
     *
     * This is an agent property.
     * @field init
     *
     */
    @Parameter (displayName = "init", usageName = "init")
    public int getInit() {
        return init
    }
    public void setInit(int newValue) {
        init = newValue
    }
    public int init = 0

    /**
     *
     * This is an agent property.
     * @field otherOp
     *
     */
    @Parameter (displayName = "otherOp", usageName = "otherOp")
    public double getOtherOp() {
        return otherOp
    }
    public void setOtherOp(double newValue) {
        otherOp = newValue
    }
    public double otherOp = 0

    /**
     *
     * This is an agent property.
     * @field opListSize
     *
     */
    @Parameter (displayName = "opListSize", usageName = "opListSize")
    public int getOpListSize() {
        return opListSize
    }
    public void setOpListSize(int newValue) {
        opListSize = newValue
    }
    public int opListSize = 0
```

```
/**
 *
 * This is an agent property.
 * @field opMean
 *
 */
@Parameter (displayName = "opMean", usageName = "opMean")
public double getOpMean() {
    return opMean
}
public void setOpMean(double newValue) {
    opMean = newValue
}
public double opMean = 0

/**
 *
 * This is an agent property.
 * @field agtPwrStat
 *
 */
@Parameter (displayName = "agtPwrStat", usageName = "agtPwrStat")
public double getAgtPwrStat() {
    return agtPwrStat
}
public void setAgtPwrStat(double newValue) {
    agtPwrStat = newValue
}
public double agtPwrStat = 0

/**
 *
 * This is an agent property.
 * @field chosenIndex
 *
 */
@Parameter (displayName = "chosenIndex", usageName = "chosenIndex")
public double getChosenIndex() {
    return chosenIndex
}
public void setChosenIndex(double newValue) {
    chosenIndex = newValue
}
public double chosenIndex = 0

/**
 *
 * This is an agent property.
 * @field totalCI
 *
 */
@Parameter (displayName = "totalCI", usageName = "totalCI")
public int getTotalCI() {
    return totalCI
}
public void setTotalCI(int newValue) {
```

```
        totalCI = newValue
    }
    public int totalCI = 0

    /**
     *
     * This is an agent property.
     * @field impact
     *
     */
    @Parameter (displayName = "impact", usageName = "impact")
    public double getImpact() {
        return impact
    }
    public void setImpact(double newValue) {
        impact = newValue
    }
    public double impact = 0

    /**
     *
     * This is an agent property.
     * @field newOpinion
     *
     */
    @Parameter (displayName = "newOpinion", usageName = "newOpinion")
    public double getNewOpinion() {
        return newOpinion
    }
    public void setNewOpinion(double newValue) {
        newOpinion = newValue
    }
    public double newOpinion = 0

    /**
     *
     * This is an agent property.
     * @field newOtherOp
     *
     */
    @Parameter (displayName = "newOtherOp", usageName = "newOtherOp")
    public double getNewOtherOp() {
        return newOtherOp
    }
    public void setNewOtherOp(double newValue) {
        newOtherOp = newValue
    }
    public double newOtherOp = 0

    /**
     *
     * This is an agent property.
     * @field newOpListSize
     *
     */
    @Parameter (displayName = "newOpListSize", usageName =
"newOpListSize")
```

```
public int getNewOpListSize() {
    return newOpListSize
}
public void setNewOpListSize(int newValue) {
    newOpListSize = newValue
}
public int newOpListSize = 0

/**
 *
 * This is an agent property.
 * @field newOpMean
 *
 */
@Parameter (displayName = "newOpMean", usageName = "newOpMean")
public double getNewOpMean() {
    return newOpMean
}
public void setNewOpMean(double newValue) {
    newOpMean = newValue
}
public double newOpMean = 0

/**
 *
 * This is an agent property.
 * @field gap1
 *
 */
@Parameter (displayName = "gap1", usageName = "gap1")
public double getGap1() {
    return gap1
}
public void setGap1(double newValue) {
    gap1 = newValue
}
public double gap1 = 0

/**
 *
 * This is an agent property.
 * @field gap2
 *
 */
@Parameter (displayName = "gap2", usageName = "gap2")
public double getGap2() {
    return gap2
}
public void setGap2(double newValue) {
    gap2 = newValue
}
public double gap2 = 0

/**
 *
 * This is an agent property.
 * @field newInfPwrStat
```

```
     *
     */
    @Parameter (displayName = "newInfPwrStat", usageName =
"newInfPwrStat")
    public double getNewInfPwrStat() {
        return newInfPwrStat
    }
    public void setNewInfPwrStat(double newValue) {
        newInfPwrStat = newValue
    }
    public double newInfPwrStat = 0

    /**
     *
     * This is an agent property.
     * @field tick
     *
     */
    @Parameter (displayName = "tick", usageName = "tick")
    public double getTick() {
        return tick
    }
    public void setTick(double newValue) {
        tick = newValue
    }
    public double tick = 0

    /**
     *
     * This value is used to automatically generate agent identifiers.
     * @field serialVersionUID
     *
     */
    private static final long serialVersionUID = 1L

    /**
     *
     * This value is used to automatically generate agent identifiers.
     * @field agentIDCounter
     *
     */
    protected static long agentIDCounter = 1

    /**
     *
     * This value is the agent's identifier.
     * @field agentID
     *
     */
    protected String agentID = "Member " + (agentIDCounter++)

    /**
     *
     * This is the step behavior.
     * @method setAttribute
     *
     */
```

```
@ScheduledMethod(
    start = 1d,
    shuffle = true
)
public def setAttribute() {

    // Define the return value variable.
    def returnValue

    // Note the simulation time.
    def time = GetTickCountInTimeUnits()

    // This is a task.
    //Uniform Distribution
    Random gen1 = new Random()
    double diff = 1 - (-1)
    setOpinion(-1 + gen1.nextDouble() * diff)
    setNewOpinion(opinion)
    //Match of Expertise
    double a = 0.5
    RandomHelper.createBinomial(1, a)
    setExptMatch(RandomHelper.getBinomial().nextInt())
    //Power and Status beta = 2
    int infPwrStat1 = gen1.nextInt(5)+1
    double infPwrStat2 = infPwrStat1
    setInfPwrStat(infPwrStat2)
    double b = 1
    double gen2 = (gen1.nextDouble())
    double base = ((pow(10, -b) - pow(1, -b))*gen2 + pow(1, -b))
    double power = 1/-b
    setFormPwrStat(pow(base, power))
    double pwrStat0 = rint(infPwrStat*formPwrStat)
    int pwrStat0A = pwrStat0
    setPwrStat(pwrStat0A)
    // This is a task.
    //initRule 2
    if (exptMatch == 1) {
    setInit(1)
    } else {
    setInit(0)
    }
    // Return the results.
    return returnValue

}

/**
 *
 * This is the step behavior.
 * @method interactions
 *
 */
@ScheduledMethod(
    start = 2d,
    interval = 1d,
    shuffle = true
)
```

```
    public def interactions() {

        // Define the return value variable.
        def returnValue

        // Note the simulation time.
        def time = GetTickCountInTimeUnits()

        // This is a task.
        //Prep for Round 3 and later with Full Fdbk
        setTick(GetTickCount())
        setInit(init)
        //Set New PwrStat & infPwrStat
        if (tick >= 3) {
        double pwrStat1 = rint(newInfPwrStat * formPwrStat)
        int pwrStat2 = pwrStat1
        setPwrStat(pwrStat2)
        setInfPwrStat(newInfPwrStat)
        } else {
        setPwrStat(pwrStat)
        setInfPwrStat(infPwrStat)
        }
        //Get OpMean and Gap2 for this round
        setOtherOp(0)
        setOpMean(0)
        setOpListSize(0)
        ArrayList<Double> listOp30A = new ArrayList<Double>()
        ContinuousSpace spaceInit30A =
FindContinuousSpace("Dissertation0/orgSpace")
        Iterator listInit30A = new ContinuousWithin(spaceInit30A, this,
72).query().iterator()
        while (listInit30A.hasNext()) {
        Object agt50A = listInit30A.next()
        double opA = agt50A.opinion
        listOp30A.add(opA)
        }
        //Mean of Opinion
         for (int j = 0; j < listOp30A.size; j++) {
        setOtherOp(otherOp + listOp30A.get(j))
        }
        setOpListSize(listOp30A.size + 1)
        setOtherOp(otherOp + opinion)
        setOpMean(otherOp/opListSize)
        setGap2(opinion - opMean)
        setGap2(abs(gap2))

        // This is an agent decision.
        if (init == 1) {

            // This is a task.
            //Three Agree
            ArrayList<Double> potEmb = new ArrayList<Double>()
            setPotEmbCounter1(0)
            setPotEmbCounter2(0)
            ContinuousSpace potEmb1 =
FindContinuousSpace("Dissertation0/orgSpace")
```

```
            Iterator listPotEmb1 = new ContinuousWithin(potEmb1, this,
72).query().iterator()
            while (listPotEmb1.hasNext()) {
            Object agt70 = listPotEmb1.next()
            double gap70 = agt70.gap2
            potEmb.add(gap70)
            setPotEmbCounter1(potEmbCounter1 + 1)
            }
             for (int i = 0; i < 3; i++) {
            double gap80 = potEmb.get(i)
            if (gap80 <= gap2) {
            setPotEmbCounter2(potEmbCounter2 + 1)
            } else {
            }
            }
            if (potEmbCounter2 >= 3) {
            setInit(1)
            } else {
            setInit(0)
            }

            // This is an agent decision.
            if (init == 1) {

                // This is a task.
                //Check for SrchRule
                ArrayList<Object> pSHigh = new ArrayList<Object>()
                ArrayList<Object> pSSame = new ArrayList<Object>()
                ArrayList<Object> pSLow = new ArrayList<Object>()
                ContinuousSpace spaceSrch1 =
FindContinuousSpace("Dissertation0/orgSpace")
                Iterator listSrch1 = new ContinuousWithin(spaceSrch1, this,
72).query().iterator()
                while (listSrch1.hasNext()) {
                Object agt20 = listSrch1.next()
                setAgtPwrStat(agt20.pwrStat)
                if (pwrStat < agtPwrStat) {
                pSHigh.add(agt20)
                } else {
                if (agtPwrStat < pwrStat) {
                pSLow.add(agt20)
                } else {
                pSSame.add(agt20)
                }
                }
                }
                // This is a task.
                //srchRule4
                ArrayList<Object> chosenList = new ArrayList<Object>()
                Iterator listPSSame = pSSame.iterator()
                while(listPSSame.hasNext()) {
                Object agt23 = listPSSame.next()
                chosenList.add(agt23)
                }
                Collections.shuffle(chosenList)
                setTotalCI(chosenList.size)
                // This is a task.
```

```
                //chgRule 3
                //Calculate the impact
                setOtherOp(0)
                setChosenIndex(0)
                ArrayList<Double> impList = new ArrayList<Double>()
                Iterator listChosen1 = chosenList.iterator()
                while (listChosen1.hasNext()) {
                Object agt30 = listChosen1.next()
                double op = agt30.opinion
                setChosenIndex(chosenIndex + 1)
                int e = agt30.exptMatch
                double ed = e
                int ps = agt30.pwrStat
                double psd = ps
                double z = 0.5
                double imp = (ed + (psd/50)) * ((totalCI - chosenIndex +
1) * 1/totalCI) * exp(-z * chosenIndex)
                impList.add(imp)
                setOtherOp(otherOp + (op * imp))
                }
                Iterator listImp1 = impList.iterator()
                while (listImp1.hasNext()) {
                double imp1 = listImp1.next()
                setImpact(impact + imp1)
                }
                //Get NewOpinion
                double impSelf = 1
                setNewOpinion((opinion * impSelf + otherOp)/(impSelf +
impact))
                // This is a task.

            } else  {

                // This is a task.

            }
            // This is a task.

        } else  {

            // This is a task.

        }
        // Return the results.
        return returnValue

    }

    /**
     *
     * This is the step behavior.
     * @method feedback
     *
     */
    @ScheduledMethod(
        start = 2d,
        interval = 1d,
```

```
        shuffle = true
    )
    public def feedback() {

        // Define the return value variable.
        def returnValue

        // Note the simulation time.
        def time = GetTickCountInTimeUnits()

        // This is a task.
        //Full FdBk for Init & nonInit
        setNewOtherOp(0)
        setNewOpMean(0)
        setNewOpListSize(0)
        ArrayList<Double> listOp30B = new ArrayList<Double>()
        ContinuousSpace spaceInit30B =
FindContinuousSpace("Dissertation0/orgSpace")
        Iterator listInit30B = new ContinuousWithin(spaceInit30B, this,
72).query().iterator()
        while (listInit30B.hasNext()) {
        Object agt50B = listInit30B.next()
        double opB = agt50B.newOpinion
        listOp30B.add(opB)
        }
        //Mean of NewOp
         for (int k = 0; k < listOp30B.size; k++) {
        setNewOtherOp(newOtherOp + listOp30B.get(k))
        }
        setNewOpListSize(listOp30B.size + 1)
        setNewOtherOp(newOtherOp + newOpinion)
        setNewOpMean(newOtherOp/newOpListSize)
        //Feedback to Init
        setGap1(newOpinion - newOpMean)
        setGap1(abs(gap1))
        if (gap2 >= gap1) {
        setInit(init)
        } else {
        setInit(1)
        }
        //Feedback to infPS
        double invgap = 1/gap1
        double ips = log(invgap)/log(100)
        setNewInfPwrStat(infPwrStat + ips)
        if (newInfPwrStat >= 5) {
        setNewInfPwrStat(5)
        } else {
        if (newInfPwrStat <= 1) {
        setNewInfPwrStat(1)
        } else {
        }
        }
        //Set Opinions for the next round
        setOpinion(newOpinion)
        // Return the results.
        return returnValue
```

```
    }

    /**
     *
     * This method provides a human-readable name for the agent.
     * @method toString
     *
     */
    @ProbeID()
    public String toString() {

        // Define the return value variable.
        def returnValue

        // Note the simulation time.
        def time = GetTickCountInTimeUnits()

        // Set the default agent identifier.
        returnValue = this.agentID
        // Return the results.
        return returnValue

    }


}
```

REFERENCES

Adner, Ron, László Pólos, Michael Ryall, and Olav Sorensen. 2009. "Introduction to Special Topic Forum: The Case for Formal Theory." *Academy of Management Review* 34:201-208.

Aldrich, Howard E. 1979. *Organizations and Environments*. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Aldrich, Howard. E., and Martin Ruef. 2006. *Organizations Evolving*. London: Sage Publications.

Alexopoulos, Christos, and Seong-Hee Kim. 2002. "Output Data Analysis for Simulations." Pp. 85-96 in *Winter Simulation Conference*, edited by E. Yücesan, C.-H. Chen, J. L. Snowdon, and J. M. Charnes: IEEE.

Allen, Natalie J., and John P. Meyer. 1990. "Organizational Socialization Tactics: A Longitudinal Analysis of Links to Newcomers' Commitment and Role Orientation." *Academy of Management Journal* 33:847-858.

Allison, Graham T. 1971. *Essence of Decision: Explaining the Cuban Missile Crisis*. Boston, MA: Little, Brown and Company.

Argote, Linda. 2005. "Reflections on Two Views of Managing Learning and Knowledge in Organizations." *Journal of Management Inquiry* 14:43-48.

Argyris, Chris, and Donald Schön. 1974. *Theory in Practice: Increasing Professional Effectiveness*. San Francisco, CA: Jossey-Bass.

Ariely, Dan. 2009. *Predictably Irrational, Revised and Expanded Edition: The Hidden Forces That Shape Our Decisions*. New York, NY: Harper Collins.

Ashforth, Blake E., and Vikas Anand. 2003. "The Normalization of Corruption in Organizations." *Research in Organizational Behavior* 25:1-52.

Ashforth, Blake E., and Alan M. Saks. 1996. "Socialization Tactics: Longitudinal Effects on Newcomer Adjustment." *Academy of Management Journal* 39:149-178.

Åström, Karl Johan, and Richard M. Murray. 2008. *Feedback Systems: An Introduction for Scientists and Engineers*. Princeton, NJ: Princeton University Press.

Baldwin, Daivd A. 1989. *Paradoxes of Power*. New York, NY: Basil Blackwell.

Ballesteros, Jose Sanchez-Alarcos. 2007. *Improving Air Safety through Organizational Learning: Consequences of a Technology-Led Model*. Burlington, VA: Ashgate Publishing Company.

Banja, John. 2010. "The Normalization of Deviance in Healthcare Delivery." *Business Horizons* 53:139-148.

Barnard, Chester I. 1938. *The Functions of the Executive*. Cambridge, MA: Harvard University Press.

Battenhausen, Kenneth, and J. Keith Murninghan. 1985. "The Emergence of Norms in Competitive Decision-Making Groups." *Administrative Science Quarterly* 30:350-372.

Baum, Joel A. C., and Krista B. Dahlin. 2007. "Aspiration Performance and Railroads' Patterns of Learning from Train Wrecks and Crashes." *Organization Science* 18:368-385.

Baumard, Philippe, and William H. Starbuck. 2005. "Learning from Failures: Why It May Not Happen." *Long Range Planning* 38:281-298.

Bazant, Zdenek P. 2001. "Why did the World Trade Center Towers Collapse?" Cambridge, MA.

Bazerman, Max H., and Michael D. Watkins. 2004. *Predictable Surprises: The Disasters You Should Have Seen Coming and How to Prevent Them*. Cambridge, MA: Harvard Business School.

Bechky, Beth A., and Gerardo A. Okhuysen. 2011. "Expecting the Unexpected? How SWAT Officers and Film Crews Handle Surprises." *Academy of Management Journal* 54:230-261.

Beck, Eckardt C. 1979. "The Love Canal Tragedy." in *EPA Journal - January 1979*: US Environmental Protection Agency.

Beck, Tammy E., and Donde Ashmos Plowman. 2009. "Experiencing Rare and Unusual Events Richly: The Role of Middle Managers in Animating and Guiding Organizational Interpretation." *Organization Science* 20:909-924.

Becker, Gary S. 1976. *The Economic Approach to Human Behavior*. Chicago, IL: The University of Chicago Press.

Becker, Markus C. 2004. "Organizational Routines: A Review of the Literature." *Industrial and Corporate Change* 13:643-677.

Becker, Markus C., Nathalie Lazaric, Richard R. Nelson, and Sidney G. Winter. 2005. "Applying Organizational Routines in Understanding Organizational Change." *Industrial and Corporate Change* 14:775-791.

Beekun, Rafik I., and William H. Glick. 2001. "Organization Structure from a Loose Coupling Perspective: A Multidimensional Approach." *Decision Sciences* 32:227-250.

Berger, Joseph, and M. Hamit Fisek. 1970. "Consistent and Inconsistent Status Characteristics and the Determination of Power and Prestige Orders." *Sociometry* 33:287-304.

Bigley, Gregory A., and Karlene H. Roberts. 2001. "The Incident Command System: High-Reliability Organizing for Complex and Volatile Task Environment." *Academy of Management Journal* 44:1281-1299.

Birkland, Thomas A. 2004. "Learning and Policy Improvement after Disaster: The Case of Aviation Security." *American Behavioral Scientist* 48:341-364.

Blau, Peter M. 1955. *The Dynamics of Bureaucracy*. Chicago, IL: The University of Chicago Press.

Bolino, Mark C. 1999. "Citizenship and Impression Management: Good Soldiers or Good Actors?" *Academy of Management Review* 24:82-98.

Bonabeau, Eric. 2002. "Agent-Based Modeling: Methods and Techniques for Simulating Human Systems." *PNAS* 99:7280-7287.

Bourgeois III, L. J., and Kathleen M. Eisenhardt. 1988. "Strategic Decision Process in High-Velocity Environments: Four Cases in the Microcomputer Industry." *Management Science* 34:816-835.

BP Investigation Team. 2005. "Fatal Accident Investigation Report: Isomerization Unit Explosion Final Report."

Bragg, Captain Robert L. 2007. "Captain Robert L. Bragg Revisits the Past - Tenerife: The Worst Commercial Aviation Accident in History, 27 March 1977." in *Runway Incursion Forum: Promoting Runway Safety*. Washington, DC.

Bragger, Jennifer DeNicolis, Donald Bragger, Donald A. Hantula, and Jean Krinan. 1998. "Hysteresis and Uncertainty: The Effect of Uncertainty on Delays to Exit Decisions." *Organizational Behavior and Human Processes* 74:229-253.

Braun, Peter, Dieter Wiegand, and Herbert Aschenbrenner. 1991. "The Assessment of Complex Skills and of Personality Characteristics in Military Services." Pp. 37-61 in *Handbook of Military Psychology*, edited by Reuven Gal and A. David Mangelsdorff. New York, NY: John Wiley & Sons.

Brockner, Joel. 1992. "The Escalation of Commitment to a Failing Course of Action: Towards Theoretical Progress." *Academy of Management Review* 17:39-61.

Bröder, Arndt, and Stefanie Schiffer. 2006. "Adaptive Flexibility and Maladaptive Routines in Selecting Fast and Frugal Decision Strategies." *Journal of Experimental Psychology: Learning, Memory, and Cognition* 32:904-918.

Brunsson, Nils. 1985. *The Irrational Organization: Irrationality as a Basis for Organizational Action and Change*. New York, NY: Wiley.

Burton, Richard M., and Borge Obel. 1995. "The Validity of Computational Models in Organization Science: From Model Realism to Purpose of the Model." *Computational and Mathematical Organization Theory* 1:57-71.

Cangelosi, Vincent E., and William R. Dill. 1965. "Organizational Learning: Observations Toward a Theory." *Administrative Science Quarterly* 10:175-203.

Cannon-Bowers, Janis A., and Eduardo Salas. 2001. "Reflections on Shared Cognition." *Journal of Organizational Behavior* 22:195-202.

Cannon, Mark D., and Amy C. Edmondson. 2001. "Confronting Failure: Antecedents and Consequences of Shared Beliefs about Failure in Organizational Groups." *Journal of Organizational Behavior* 22:161-177.

—. 2005. "Failing to Learn and Learning to Fail (Intelligently): How Great Organizations Put Failure to Work to Innovate and Improve." *Long Range Planning* 38:299-319.

Carley, Kathleen. 1996. "Organizational Learning and Personnel Turnover." Pp. 230-266 in *Organizational Learning*, edited by Michael D. Cohen and Lee S. Sproull. Thousand Oaks, CA: Sage Publications.

Carley, Kathleen M. 2002. "Intraorganizational Complexity and Computation." Pp. 208-232 in *Companion to Organizations*, edited by Joel A. C. Baum. Malden, MA: Blackwell Publishing.

Carroll, J. S., and Amy C. Edmondson. 2002. "Leading Organizational Learning in Health Care." *Quality and Safety in Health Care* 11:51-56.

Casamayou, Maureen Hogan. 1993. *Bureaucracy in Crisis: Three Mile Island, the Shuttle Challenger, and Risk Assessment*. Boulder, CO.: Westview Press, Inc.

Centola, Damon, Robb Willer, and Michael Macy. 2005. "The Emperor's Dilemma: A Computational Model of Self-Enforcing Norms." *American Journal of Sociology* 110:1009-1040.

Chandler, Jr., Alfred D. 1962. *Strategy and Structure: Chapters in the History of the American Industry Enterprise*. Cambridge, MA.: The MIT Press.

Chao, Georgia T., Anne M. O'Leary-Kelly, Samantha Wolf, Howard J. Klein, and Philip D. Gardner. 1994. "Organizational Socialization: Its Content and Consequences." *Journal of Applied Psychology* 79:730-743.

Chatman, Jennifer A. 1991. "Matching People and Organizations: Selection and Socialization in Accounting Firms." *Administrative Science Quarterly* 36:459-494.

Christianson, Marlys K., Maria T. Farkas, Kathleen M. Sutcliffe, and Karl E. Weick. 2009. "Learning through Rare Events: Significant Interruptions at the Baltimore & Ohio Railroad Museum." *Organization Science* 20:846-860.

Clauset, Aaron, Cosma Rohilla Shalizi, and M. E. J. Newman. 2009. "Power-Law Distributions in Empirical Data." *SIAM Review* 51:661-703.

Cohen, Michael D. 1981. "The Power of Parallel Thinking." *Journal of Economic Behavior and Organization* 2:285-306.

—. 1996. "Individual Learning and Organizational Routine: Emerging Connections." Pp. 188-194 in *Organizational Learning*, edited by Michael D. Cohen and Lee S. Sproull. Thousand Oaks, CA: Sage Publications.

Cohen, Michael D., and Paul Bacdayan. 1996. "Organizational Routines Are Stored as Procedural Memory: Evidence from a Laboratory Study." Pp. 403-429 in *Organizational Learning*, edited by Michael D. Cohen and Lee S. Sproull. Thousand Oaks, CA: Sage Publications.

Cohen, Michael D., James G. March, and Johan P. Olsen. 1972. "A Garbage Can Model of Organizational Choice." *Administrative Science Quarterly* 17:1-25.

Cohen, Wesley, M., and Daniel A. Levinthal. 1990. "Absorptive Capacity: A New Perspective on Learning and Innovation." *Administrative Science Quarterly* 35:128-152.

Columbia Accident Investigation Board. 2003. "The CAIB Report."

Comfort, Louise K., Kilkon Ko, and Adam Zagorecki. 2004. "Coordination in Rapidly Evolving Disaster Response Systems: the Role of Information." *American Behavioral Scientist* 48:295-313.

Cook, Karen S., Linda D. Molm, and Toshio Yamagishi. 1993. "Exchange Relations and Exchange Networks: Recent Developments in Social Exchange Theory." Pp. 296-322 in *Theoretical Research Programs*, edited by Joseph Berger and Jr. Zeldith, Morris. Stanford, CA: Stanford University Press.

Cook, Scott D. N., and Dvora Yanow. 1996. "Culture and Organizational Learning." Pp. 430-459 in *Organizational Learning*, edited by Michael D. Cohen and Lee S. Sproull. Thousand Oaks, CA: Sage Publications.

Cooper, Christopher, and Robert Block. 2006. *Disaster: Hurricane Katrina and the Failure of Homeland Security*. New York, NY: Times Holt.

Côté, Stéphane, and Christopher T. H. Miners. 2006. "Emotional Intelligence, Cognitive Intelligence, and Job Performance." *Administrative Science Quarterly* 51:1-28.

Cox, Sue, Bethan Jones, and David Collinson. 2006. "Trust Relations in High-Reliability Organizations." *Risk Analysis* 26:1123-1138.

Cyert, Richard M., and James G. March. 1963. *A Behavioral Theory of the Firm*. Englewood Cliffs, NJ: Prentice-Hall.

Cyert, Richard. M., William. R. Dill, and James G. March. 1958. "The Role of Expectations in Business Decision Making." *Administrative Science Quarterly* 3:307-340.

Daft, Richard L., and Karl E. Weick. 1984. "Toward a Model of Organizations as Interpretation Systems." *Academy of Management Review* 9:284-295.

Dahl, Robert A. 1963. *Modern Political Analysis*. Englewood Cliffs, NJ: Prentice-Hall.

Davis-Blake, Alison, and Jeffrey Pfeffer. 1989. "Just a Mirage: The Search for Dispositional Effects in Organizational Research." *The Academy of Management Review* 14:385-400.

Davis, Jason P., Kathleen M. Eisenhardt, and Christopher B. Bingham. 2007. "Developing Theory Through Simulation Methods." *Academy of Management Review* 32:480-499.

Denrell, Jerker. 2003. "Vicarious Learning, Undersampling of Failure, and the Myth of Management." *Organization Science* 14:227-243.

Denrell, Jerker, and James G. March. 2001. "Adaptations as Information Restriction: The Hot Stove Effect." *Organization Science* 12:523-538.

DiMaggio, Paul. 1997. "Culture and Cognition." *Annual Review of Sociology* 23:263-287.

DiMaggio, Paul J., and Walter W. Powell. 1983. "The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields." *American Sociological Review* 48:147-160.

Dooley, Kevin. 2002. "Simulation Research Method." Pp. 304-326 in *Companion to Organizations*, edited by Joel A. C. Baum. Malden, MA: Blackwell Publishing.

Downer, John. 2010. "On Unforeseeable Future." *Risk & Regulation*:6-7.

Drennan, RADM Frank M. 2008. "Command Investigation into the Fire that Occurred onboard USS George Washington (CVN 73) on 22 May 2008." US Navy.

Dunbar, Roger L. M., and Raghu Garud. 2009. "Distributed Knowledge and Indeterminate Meaning: The Case of the Columbia Shuttle Flight." *Organization Studies* 30:397-421.

Edmondson, Amy. 1999. "Psychological Safety and Learning Behavior in Work Teams." *Administrative Science Quarterly* 44:350-383.

Edmondson, Amy C. 2002. "The Local and Variegated Nature of Learning in Organizations: A Group-Level Perspective." *Organization Science* 13:128-146.

Edmondson, Amy C., Richard M. Bohmer, and Gary P. Pisano. 2001. "Disrupted Routines: Team Learning and New Technology Implication in Hospitals." *Administrative Science Quarterly* 46:685-716.

Edmondson, Amy C., and Bertrand Moingeon. 1998. "From Organizational Learning to Learning Organization." *Management Learning* 29:5-20.

Eisenhardt, Kathleen M. 1989a. "Agency Theory: An Assessment and Review." *The Academy of Management Review* 14:57-74.

—. 1989b. "Making Fast Strategic Decisions in High-Velocity Environments." *Academy of Management Journal* 32:543-576.

Eisenhardt, Kathleen M., and L. J. Bourgeois III. 1988. "Politics of Strategic Decision-Making in High-Velocity Environments: Toward a Midrange Theory." *Academy of Management Journal* 31:737-770.

Eisenhardt, Kathleen M., and Jeffrey A. Martin. 2000. "Dynamic Capabilities: What are They?" *Strategic Management Journal* 21:1105-1121.

Elsbach, Kimberly D., Pamela S. Barr, and Andrew B. Hargadon. 2005. "Identifying Situated Cognition in Organizations." *Organization Science* 16:422-433.

Epstein, Joshua M. 2006. *Generative Social Science: Studies in Agent-Based Computational Modeling*. Princeton, NJ: Princeton University Press.

Esser, James K. 1998. "Alive and Well after 25 Years: A Review of Groupthink Research." *Organizational Behavior and Human Decision Processes* 73:116-141.

Farber, Daniel A. 2010. "Uncertainty." Pp. 1-55 in *UC Berkeley Public Law Research Paper*. Berkeley, CA: University of California, Berkeley.

Feldman, Daniel C. 1984. "The Development and Enforcement of Group Norms." *Academy of Management Review* 9:47-53.

Feldman, Martha S. 2000. "Organizational Routines as a Source of Continuous Change." *Organization Science* 11:611-629.

—. 2003. "A Performance Perspective on Stability and Change in Organizational Routines." *Industrial and Corporate Change* 12:727-752.

Feldman, Martha S., and James G. March. 1981. "Information in Organizations as Signal and Symbol." *Administrative Science Quarterly* 26:171-186.

Feldman, Martha S., and Brian T. Pentland. 2003. "Reconceptualizing Organizational Routines as a Source of Flexibility and Change." *Administrative Science Quarterly* 48:94-118.

Fiol, C. Marlene, and Marjorie A. Lyles. 1985. "Organizational Learning." *Academy of Management Review* 10:803-813.

Fischhoff, Baruch. 2006. "Behaviorally Realistic Risk Management." Pp. 77-88 in *On Risk and Disaster: Lessons from Hurricane Katrina*, edited by Ronald J. Daniels, Donald F. Kettl, and Howard Kunreuther. Philadelphia, PA: University of Pennsylvania Press.

Forbes, Daniel P. 2007. "Reconsidering the Strategic Implications of Decision Comprehensiveness." *Academy of Management Review* 32:361-376.

Gaba, David M. 2000. "Structural and Organizational Issues in Patient Safety: A Comparison of Health Care to Other High-Hazard Industries." *California Management Review* 43:83-102.

Gavetti, Giovanni, Daniel Levinthal, and William Ocasio. 2007. "Neo-Carnegie: The Carnegie School's Past, Present, and Reconstructing for the Future." *Organization Science* 18:523-536.

Gersick, Connie J. G., and J. Richard Hackman. 1990. "Habitual Routines in Task-Performing Groups." *Organizational Behavior and Human Decision Processes* 47:65-97.

Gerstein, Marc. 2008. *Flirting with Disaster: Why Accidents are Rarely Accidental*. New York, NY: Sterling Publishing Co., Inc.

Gigerenzer, G., J. Czeslinski, and L. Martignon. 1999. "How Good are Fast and Frugal Heuristics?" Decision Science and Technology." in *Heuristics and Biases (2002)*, edited by T. Gilovich, D. Griffin, and D. Kahneman. Cambridge: Cambridge University Press.

Gilbert, Nigel. 2007. *Agent-Based Models*. London: Sage Publications.

Gilbert, Nigel, and Klaus G. Troitzsch. 2005. *Simulation for the Social Scientist*. New York, NY: Open University Press.

Gilboa, Itzhak. 2009. *Theory of Decision under Uncertainty*. New York, NY: Cambridge University Press.

Gioia, Dennis A. 1992. "Pinto Fires and Personal Ethics: A Script Analysis of Missed Opportunities." *Journal of Business Ethics* 11:379-389.

Goldsman, Dave. 2010. "Simulation Output Analysis." Atlanta, GA: School of ISyE, Georgia Tech.

Gouldner, Alvin W. 1954. *Patterns of Industrial Bureaucracy: A Case Study of Modern Factory Administration*. New York, NY: The Free Press.

Grabowski, Martha, and Karlene H. Roberts. 1997. "Risk Mitigation in Large-Scale Systems: Lessons from High Reliability Organizations." *California Management Review* 39:152-162.

Hamel, Gary, and Bill Breen. 2007. *The Future of Management*. Cambridge, MA: Harvard Business School Press.

Hampton, Keith N., Lauren F. Sessions, and Eun Ja Her. 2011. "Core Networks, Social Isolation, and New Media." *Information, Communication & Society* 14:130-155.

Harvard Business Review. 2011. "The Failure Issue: How to Understand it, Learn from it, and Recover from it." Boston, MA.

Hatch, Mary Jo. 1999. "Exploring the Empty Spaces of Organizing: How Improvisational Jazz Helps Redescribe Organizational Structure." *Organization Studies* 20:75-100.

Haunschild, Pamela R., and Bilian Ni Sullivan. 2002. "Learning from Complexity Effects of Prior Accidents and Incidents on Airlines' Learning." *Administrative Science Quarterly* 47:609-643.

Heath, Chip, Richard P. Larrick, and Joshua Klayman. 1998. "Cognitive Repairs: How Organizational Practice can Compensate for Individual Shortcomings." *Research in Organizational Behavior* 20:1-37.

Herriott, Scott R., Daniel A. Levinthal, and James G. March. 1985. "Learning from Experience in Organizations." *American Economic Review* 75:298-302.

Hofmann, David A., and Lisa A. Jones. 2005. "Leadership, Collective Personality, and Performance." *Journal of Applied Psychology* 90:509-522.

Homans, George C. 1958. "Social Behavior as Exchange." *American Journal of Sociology* 63:597-606.

Hopkins, Andrew. 2010. "Why BP Ignored Close Calls at Texas City." *Risk & Regulation*:4-5.

Howard-Granville, Jennifer A. 2005. "The Persistence of Flexible Organizational Routines: The Role of Agency and Organizational Context." *Organization Science* 16:618-636.

Huber, George P. 1996. "Organizational Learning: The Contributing Process and the Literatures." Pp. 124-162 in *Organizational Learning*, edited by Michael D. Cohen and Lee S. Sproull. Thousand Oaks, CA: Sage Publications.

Isenberg, Daniel J. 1986. "Group Polarization: A Critical Review and Meta-Analysis." *Journal of Personality and Social Psychology* 50:1141-1151.

Janis, I. L. 1972. *Victims of Groupthink: A Psychological Study of Foreign-Policy Decisions and Fiascoes*. Boston, MA: Houghton Mifflin.

—. 1983. *Groupthink: Psychological Studies of Policy Decisions and Fiascoes*. Boston. MA: Houghton Mifflin.

Jarman, Alan. 2001. "'Reliability' Reconsidered: A Critique of the HRO-NAT Debate." *Journal of Contingencies and Crisis Management* 9:98-107.

Johnson, Liz. 2010. *Agent-Based Modeling Overview: A Guide for Effective Modeling for Political Science and Policy Researchers*. Charlotte, NC: Complex Systems Institute, University of North Carolina at Charlotte.

Kahneman, Daniel, and Amos Tversky. 1979. "Prospect Theory: An Analysis of Decision under Risk." *Econometrica* 47:263-291.

—. 1984. "Choices, Values, and Frames." *American Psychologist* 39:341-350.

Kelton, David W. 1997. "Statistical Analysis of Simulation Output." Pp. 23-30 in *Winter Simulation Conference*, edited by A. Andoraclóttir, K. J. Healy, D. H. Withers, and B. L. Nelson: IEEE.

Kim, Ji-Yub (Jay), and Anne S. Miner. 2007. "Vicarious Learning from the Failures and Near-Failures of Others: Evidence from the US Commercial Banking Industry." *Academy of Management Journal* 50:687-714.

Knight, Frank H. 1921. *Risk, Uncertainty, and Profit*. Boston, MA: Hart, Schaffner & Marx; Houghton Mifflin Co.

Kogut, Bruce, and Udo Zander. 1992. "Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology." *Organization Science* 3:383-397.

Lampel, Joseph, Jamal Shamsie, and Zur Shapira. 2009. "Experiencing the Improbable: Rare Events and Organizational Learning." *Organization Science* 20:835-845.

Lane, Peter J., and Michael Lubatkin. 1998. "Relative Absorptive Capacity and Interorganizational Learning." *Strategic Management Journal* 19:461-477.

Lant, Theresa K., and Stephen J. Mezias. 1996. "An Organizational Learning Model of Convergence and Reorientation." Pp. 267-301 in *Organizational Learning*, edited by Michael D. Cohen and Lee S. Sproull. Thousand Oaks, CA: Sage Publications.

LaPorte, Todd R., and Paula M. Consolini. 1991. "Working in Practice but Not in Theory: Theoretical Challenges of "High-Reliability Organizations"." *Journal of Public Administration Research and Theory: J-PART* 1:19-48.

Latané, Bibb. 1981. "The Psychology of Social Impact." *American Psychologist* 36:343-356.

Latané, Bibb, and Steve Nida. 1981. "Ten Years of Research on Group Size and Helping." *Psychological Bulletin* 89:308-324.

Law, Averill M. 2006a. *Simulation Modeling and Analysis*. New York, NY: McGraw-Hill.

—. 2006b. "Statistical Analysis of the Output Data from Terminating Simulations." *Naval Research Logistics Quarterly* 27:131-143.

Lee, Fiona, Amy C. Edmondson, Stefan Thomke, and Monica Worline. 2004. "The Mixed Effects of Inconsistency on Experimentation in Organizations." *Organization Science* 15:310-326.

Levin, Alan, Marilyn Adams, and Brake Morrison. 2011. "Four Hours of Fear; A Drastic Order: Clear the Skies." in *USA Today*. McLean, VA.

Levinthal, Daniel A. 1996. "Organizational Adaptation and Environmental Selection: Interrelated Processes of Change." Pp. 195-202 in *Organizational Learning*, edited by Michael D. Cohen and Lee S. Sproull. Thousand Oaks, CA: Sage Publications.

Levinthal, Daniel A., and James G. March. 1993. "The Myopia of Learning." *Strategic Management Journal* 14:95-112.

Levinthal, Daniel A., and Claus Rerup. 2006. "Crossing an Apparent Chasm: Bridging Mindful and Less-Mindful Perspectives on Organizational Learning." *Organization Science* 17:502-513.

Levitt, Barbara, and James G. March. 1988. "Organizational Learning." *Annual Review of Sociology* 14:319-338.

Lomi, Alessandro, Erik R. Larsen, and Ari Ginsberg. 1997. "Adaptive Learning in Organizations: A System Dynamics-Based Exploration." *Journal of Management* 23:561-582.

Louis, Meryl Reis. 1980. "Surprise and Sense Making: What Newcomers Experience in Entering Unfamiliar Organizational Settings." *Administrative Science Quarterly* 25:226-251.

Louis, Meryl Reis, Barry Z. Posner, and Gary N. Powell. 1983. "The Availability and Helpfulness of Socialization Practices." *Personnel Psychology* 36:857-866.

Lounamaa, Pertti H., and James G. March. 1987. "Adaptive Coordination of a Learning Team." *Management Science* 33:107-123.

Lutfey, Karen, and Jeylan T. Mortimer. 2003. "Development and Socialization through the Adult Life Course." Pp. 183-202 in *Handbook of Social Psychology*, edited by John Delamater. Madison, WI: Springer.

Macal, Charles M., and Michael J. North. 2005. "Tutorial on Agent-Based Modeling and Simulation." Pp. 2-15 in *2005 Winter Simulation Conference*, edited by M. E. Kuhl, N. M. Steiger, F. B. Armstrong, and J. A. Noines: IEEE.

—. 2006. "Tutorial on Agent-Based Modeling and Simulation Part 2: How to Model with Agents." Pp. 73-83 in *2006 Winter Simulation Conference*, edited by L. F. Perrone, F. P. Wieland, J. Liu, B. G. Lawson, D. M. Nicol, and R. M. Fujimoto: IEEE.

—. 2007. "Agent-Based Modeling and Simulation: Desktop ABMS." in *2007 Winter Simulation Conference*, edited by S. G. Henderson, B. Biller, M.-H. Hsieh, J. Shortle, J. D. Tew, and R. R. Barton: IEEE.

Macrae, Carl. 2010. "Constructing Near Misses: Proximity, Distance and the Space Between." *Risk & Regulation*:10-11.

Macy, Michael W., and Robert Willer. 2002. "From Factors to Actors: Computational Sociology and Agent-Based Modeling." *Annual Review of Sociology* 28:143-166.

Madsen, Peter M. 2009. "These Lives Will Not Be Lost in Vain: Organizational Learning from Disaster in US Coal Mining." *Organization Science* 20:861-875.

Magee, Joe C., and Adam D. Galinsky. 2008. "Social Hierarchy: The Self-Reinforcing Nature of Power and Status." Pp. 351-398 in *The Academy of Management Annals*, edited by James P. Walsh and Arthur P. Brief: Routledge.

Mahler, Julianne G. with Maureen Hogan Casamayou. 2009. *Organizational Learning at NASA: The Challenger & Columbia Accidents*. Washington, DC: Georgetown University Press.

Maitlis, Sally, and Scott Sonenshein. 2010. "Sensemaking in Crisis and Change: Inspiration and Insights from Weick (1988)." *Journal of Management Studies* 47:551-580.

March, James G. 1991. "Exploration and Exploitation in Organizational Learning." *Organization Science* 2:71-87.

March, James G., and Johan P. Olsen. 1975. "The Uncertainty of the Past: Organizational Learning under Uncertainty." *European Journal of Political Research* 3:147-171.

—. 2004. "The Logic of Appropriateness." Pp. 1-28. Oslo, Norway: Center for European Studies, University of Oslo.

March, James G., and Herbert A. Simon. 1958. *Organizations*. New York, NY: John Wiley & Sons.

March, James G., Lee S. Sproull, and Michael Tamuz. 1996. "Learning from Samples of One or Fewer." Pp. 1-19 in *Organizational Learning*, edited by Michael D. Cohen and Lee S. Sproull. Thousand Oaks, CA: Sage Publications.

Marsden, Peter V. 1987. "Core Discussion Networks of Americans." *American Sociological Review* 52:122-131.

McCauley, Clark. 1989. "The Nature of Social Influence in Groupthink: Compliance and Internalization." *Journal of Personality and Social Psychology* 57:250-260.

McPherson, Miller, Lynn Smith-Lovin, and Matthew E. Brashears. 2006. "Social Isolation in America: Changes in Core Discussion Networks over Two Decades." *American Sociological Review* 71:353-375.

McShane, Steven L., and Mary Ann Von Glinow. 2005. *Organizational Behavior: Emerging Realities for the Workplace Revolution*. New York, NY: McGraw-Hill/Irwin.

Merton, Robert K. 1940. "Bureaucratic Structure and Personality." *Social Forces* 18:560-568.

—. 1957. "Bureaucratic Structure and Personality." Pp. 195-206 in *Social Theory and Social Structure*. Glencoe, IL: Free Press.

—. 1968. "The Matthew Effect in Science." *Science* 159:56-63.

Meyer, Robert J. 2006. "Why We Under-Prepare for Hazards." Pp. 153-173 in *On Risk and Disaster: Lessons from Hurricane Katrina*, edited by Ronald J. Daniels, Donald F. Kettl, and Howard Kunreuther. Philadelphia, PA: University of Pennsylvania Press.

Milgram, Norman A. 1991. "Personality Factors in Military Psychology." Pp. 559-572 in *Handbook of Military Psychology*, edited by Reuven Gal and A. David Mangelsdorff. New York, NY: John Wiley & Sons.

Miller, Danny. 1993. "The Architecture of Simplicity." *Academy of Management Review* 18:116-138.

—. 1994. "What Happens after Success: The Perils of Excellence." *Journal of Management Studies* 31:325-358.

Milliken, Frances J. 1987. "Three Types of Perceived Uncertainty about the Environment: State, Effect, and Response Uncertainty." *Academy of Management Review* 12:133-143.

Milliken, Frances J., Elizabeth Wolfe Morrison, and Patricia F. Hewlin. 2003. "An Exploratory Study of Employee Silence: Issues that Employees Don't Communicate Upward and Why." *Journal of Management Studies* 40:1453-1476.

Miner, Anne S., and Stephen J. Mezias. 1996. "Ugly Duckling No More: Pasts and Futures of Organizational Learning Research." *Organization Science* 7:88-99.

Mitzenmacher, Michael. 2003. "A Brief History of Generative Models for Power Law and Lognormal Distributions." *Internet Mathematics* 1:226-251.

Morris, Michael W., and Paul C. Moore. 2000. "The Lessons We (Don't) Learn: Counterfactual Thinking and Organizational Accountability after a Close Call." *Administrative Science Quarterly* 45:737-765.

Morrison, Elizabeth W. 1993. "Newcomer Information-Seeking: Exploring Types, Modes, Sources, and Outcomes." *Academy of Management Journal* 36:557-589.

—. 2006. "Doing the Job Well: An Investigation of Pro-Social Rule Breaking." *Journal of Management* 32:5-28.

Morrison, Elizabeth Wolfe, and Frances J. Milliken. 2000. "Organizational Silence: A Barrier to Change and Development in a Pluralistic World." *Academy of Management Review* 25:706-725.

Nadkarni, Sucheta, and V. K. Narayanan. 2007. "The Evolution of Collective Strategy Frames in High- and Low-Velocity Industries." *Organization Science* 18:688-710.

Nakayama, Marvin K. 2008. "Statistical Analysis of Simulation Output." Pp. 62-72 in *Winter Simulation Conference*, edited by S. J. Mason, R. R. Hill, L. Mönch, O. Rose, T. Jefferson, and J. W. Fowler: IEEE.

National Commission on Terrorist Attacks upon the United States. 2004. "The 9/11 Commission Report." Washington, DC.

National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. 2011. "Deep Water: The Gulf Oil Disaster and the Future of Offshore Drilling Report to the President."

Nelson, Richard R., and Sidney G. Winter. 1982. *An Evolutionary Theory of Economic Change*. Cambridge, MA: Belknap Press.

North, Michael J., and Charles M. Macal. 2007a. *Managing Business Complexity: Discovering Strategic Solutions with Agent-Based Modeling and Simulation*. New York, NY: Oxford University Press.

—. 2007b. *Managing Business Complexity: Discovering Strategic Solutions with Agent-Based Modeling and Simulation*. New York, NY: Oxford University Press.

Nystrom, Paul C., and William H. Starbuck. 1984. "To Avoid Organizational Crisis, Unlearn." *Organizational Dynamics* Spring 1984:53-65.

Odom-Forren, Jan. "The Normalization of Deviance: A Threat to Patient Safety." *Journal of Perianesthesia Nursing* 26:216-219.

Okhuysen, Gerardo A., and Beth A. Bechky. 2009. "Coordination in Organizations: An Integrative Perspective." *Academy of Management Annals* 3:463-502.

Oktem, Ulku G., Rafael Wong, and Cigdem Oktem. 2010. "Near-Miss Management: Managing the Bottom of the Risk Pyramid." *Risk & Regulation*:12-13.

Ostroff, Cheri, and Steve W. J. Kozlowski. 1992. "Organizational Socialization as a Learning Process: The Role of Information Acquisition." *Personnel Psychology* 45:849-874.

Pedone, Roberto, and Rosaria Conte. 2001. "Dynamics of Status Symbols and Social Complexity." *Social Science Computer Review* 19:249-262.

Pentland, Brian T., and Martha S. Feldman. 2005. "Organizational Routines as a Unit of Analysis." *Industrial and Corporate Change* 14:793-815.

Perin, Constance. 1995. "Organizations as Contexts: Implications for Safety Science and Practice." *Organization Environment* 9:152-174.

Perrow, Charles. 1986. *Complex Organizations: A Critical Essay*. New York, NY: McGraw-Hill.

—. 1999. *Normal Accidents: Living with High-Risk Technologies*. Princeton, NJ: Princeton University Press.

—. 2007. *The Next Catastrophe: Reducing Our Vulnerabilities to Natural, Industrial, and Terrorist Disasters*. Princeton, NJ: Princeton University Press.

Petty, Richard E., Stephen G. Harkins, Kipling D. Williams, and Bibb Latané. 1977. "The Effects of Group Size on Cognitive Effort and Evaluation." *Personality and Social Psychology Bulletin* 3:579-582.

Pfeffer, Jeffrey, and Robert I. Sutton. 2000. *The Knowing-Doing Gap: How Smart Companies Turn Knowledge into Action*. Boston, MA: Harvard Business School Press.

Phimister, James R., Ulku Oktem, Paul R. Kleindorfer, and Howard Kunreuther. 2003. "Near-Miss Incident Management in the Chemical Process Industry." *Risk Analysis* 23:445-459.

Picano, James J., Thomas J. Williams, and Robert R. Roland. 2006. "Assessment and Selection of High-Risk Operational Personnel." Pp. 353-370 in *Military Psychology: Clinical and Operational Applications*, edited by Carrie H. Kennedy and Eric A. Zillmer. New York, NY: Guilford Publications.

Polanyi, Michael. 1966. *The Tacit Dimension*. Garden City, NY: Anchor Books.

Presidential Commission on the Space Shuttle Challenger Accident. 1986. "Report of the Presidential Commission on the Space Shuttle Challenger Accident."

Prielipp, Richard C., Maria Magro, Robert C. Morell, and Sorin J. Brull. 2009. "The normalization of deviance: do we (un)knowingly accept doing the wrong thing?" *AANA Journal* 78:284-7.

Ramanujam, Rangaraj, and Paul S. Goodman. 2003. "Latent Errors and Adverse Organizational Consequences: A Conceptualization." *Journal of Organizational Behavior* 24:815-836.

Rath Jr., Frank H., and James E. McCarroll. 1991. "Clinical Psychological Assessment." Pp. 579-592 in *Handbook of Military Psychology* edited by Reuven Gal and A. David Mangelsdorff. New York, NY: John Wiley & Sons.

Reason, James. 1990. "The Contribution of Latent Human Failures to the Breakdown of Complex Systems." *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences* 327:475-484.

—. 1995a. "A Systems Approach to Organizational Error." *Ergonomics* 38:1708-1721.

—. 1995b. "Understanding Adverse Events: Human Factors." *Quality in Health Care* 4:80-89.

Repenning, Nelson P., and John D. Sterman. 2001. "Nobody Ever Gets Credit for Fixing Problems that Never Happened: Creating and Sustaining Process Improvement." *California Management Review* 43:64-88.

Rerup, Claus. 2006. "Success, Failure and the Gray Zone: How Organizations Learn or Don't from Ambiguous Experience." *Academy of Management Best Conference Paper 2006* OMT:BB1-BB6.

—. 2009. "Attentional Triangulation: Learning from Unexpected Rare Cases." *Organization Science* 20:876-893.

Rerup, Claus, and Martha S. Feldman. 2011. "Routines as a Source of Change in Organizational Schemata: The Role of Trial-and-Error Learning." *Academy of Management Journal* 54:577-610.

Roberto, Michael A., Richard M. J. Bohmer, and Amy C. Edmondson. 2006. "Facing Ambiguous Threats." *Harvard Business Review* 84:106-113.

Roberts, Karlene H. 1990. "Managing High Reliability Organizations." *California Management Review* 32:101-113.

Rosness, Ragnar. 2009. "A Contingency Model of Decision-Making Involving Risk of Accidental Loss." *Safety Science* 47:807-812.

Ross, Jerry, and Barry M. Staw. 1986. "Expo 86: An Escalation Prototype." *Administrative Science Quarterly* 31:274-297.

Rousseau, Denise M. 1985. "Issues of Level in Organizational Research: Multi-Level and Cross-Level Perspectives." *Research in Organizational Behavior* 7:1-37.

Sagan, Scott Douglas. 1993. *The Limits of Safety : Organizations, Accidents, and Nuclear Weapons*. Princeton, NJ: Princeton University Press.

Salvato, Carlo, and Claus Rerup. 2011. "Beyond Collective Entities: Multilevel Research on Organizational Routines and Capabilities." *Journal of Management* 37:468-490.

Schein, Edgar H. 1990. "Organizational Culture." *American Psychologist* 45:109-119.

Schoorman, F. David, and Patricia J. Holahan. 1996. "Psychological Antecedents of Escalation Behavior: Effects of Choice, Responsibility, and Decision Consequences." *Journal of Applied Psychology* 81:786-794.

Schulz, Martin. 2002. "Organizational Learning." Pp. 415-442 in *The Blackwell Companion to Organizations*, edited by Joel A. C. Baum. Malden, MA: Blackwell Publishing.

Schwartz, Gary T. 1990-1991. "The Myth of the Ford Pinto Case." *Rutgers Law Review* 43:1013-1068.

Scott, W. Richard. 1981. *Organizations: Rational, Natural, and Open Systems*. Upper Side River, NJ: Pearson Education.

Select Bipartisan Committee to Investigate the Preparation for and Response to Hurricane Katrina. 2006. "A Failure of Initiative." U.S. House of Representatives.

Selznick, Philip. 1947. *TVA and the Grass Roots: A Study in the Sociology of Formal Organization*. New York, NY: Harper & Row.

Shrivastava, Paul. 1983. "A Typology of Organizational Learning Systems." *Journal of Management Studies* 20:7-28.

Simon, Herbert A. 1947. *Administrative Behavior: A Study of Decision-Making Processes in Administrative Organization*. New York, NY: Macmillan Company.

—. 1955. "A Behavioral Model of Rational Choice." *Quarterly Journal of Economics* 69:7-19.

Sitkin, Sim B. 1992. "Learning through Failure: the Strategy of Small Losses." *Research in Organizational Behavior* 14:231-266.

Sitkin, Sim B., and Amy L. Pablo. 1992. "Reconceptualizing the Determinants of Risk Behavior." *Academy of Management Review* 17:9-38.

Sitkin, Sim B., Kathleen M. Sutcliffe, and Roger G. Schroeder. 1994. "Distinguishing Control from Learning in Total Quality Management: A Contingency Perspective." *Academy of Management Review* 19:537-564.

Sluss, David M., Robert E. Ployhart, M. Glenn Cobb, and Blake E. Ashforth. 2012. "Generalizing Newcomers' Relational and Organizational Identifications: Processes and Prototypicality." *Academy of Management Journal* 55:949-975.

Snook, Scott A. 2000. *Friendly Fire: The Accidental Shootdown of U.S. Black Hawks over Northern Iraq*. Princeton, NJ: Princeton University Press.

Starbuck, William H. 1965. "Organizational Growth and Development." in *Handbook of Organizations*, edited by James G. March. Chicago, IL: Rand McNally & Company.

—. 1982. "Congealing Oil: Inventing Ideologies to Justify Acting Ideologies Out." *Journal of Management Studies* 19:3-27.

—. 1983. "Organizations as Action Generators." *American Sociological Review* 48:91-102.

—. 2009. "Cognitive Reactions to Rare Events: Perceptions, Uncertainty, and Learning." *Organization Science* 20:925-937.

Starbuck, William H., and Moshe Farjoun (Eds.). 2005. *Organization at the Limit: Lessons from the Columbia Disaster*. Malden, MA: Blackwell Publishing.

Starbuck, William H., and Frances J. Milliken. 1988. "Challenger: Fine-Tuning the Odds until Something Breaks." *Journal of Management Studies* 25:319-340.

Staw, Barry M. 1976. "Knee-Deep in the Big Muddy: A Study of Escalating Commitment to a Chosen Course of Action." *Organizational Behavior and Human Performance* 16:27-44.

Staw, Barry M., and Frederick V. Fox. 1977. "Escalation: The Determinants of Commitment to a Chosen Course of Action." *Human Relations* 30:431-450.

Staw, Barry M., Lance E. Sandelands, and Jane E. Dutton. 1981. "Threat-Rigidity Effects in Organizational Behavior: A Multi-Level Analysis." *Administrative Science Quarterly* 26:501-524.

Stevens, S. S. 1966. "A Metric for the Social Consensus." *Science, New Series* 151:530-541.

Stoss, Fred, and Carole Ann Fabian. 1998. "About Love Canal: Background Information." Buffalo, NY: University at Buffalo University Archives.

Sunstein, Cass R. 2007. "Group Polarization and 12 Angry Men." *Negotiation Journal* 23:443-447.

Sutton, Robert I, and Barry M. Staw. 1995. "What theory is *Not*." *Administrative Science Quarterly* 40:371-384.

Taleb, Nassim Nicholas. 2007. *The Black Swan: The Impact of the Highly Improbable*. New York, NY: Random House.

Tamuz, Michael. 1987. "The Impact of Computer Surveillance on Air Safety Reporting." *Columbia Journal of World Business* 22:69-77.

Tamuz, Michael, and Michael I. Harrison. 2006. "Improving Patient Safety in Hospitals: Contributions of High-Reliability Theory and Normal Accident Theory." *Health Services Research* 41:1654-1676.

Tetlock, Philip E. 1985. "Accountability: The Neglected Social Context of Judgment and Choice." *Research in Organizational Behavior* 7:297-332.

The BP US Refineries Independent Safety Review Panel. 2007. "The Report of the BP US Refineries Independent Safety Review Panel."

The National Institute of Standards and Technology (NIST). 2011. "World Trade Center Disaster Study." Washington, DC.

The Royal Society. 1992. "Risk: Analysis, Perception and Management." in *Report of a Royal Society Study Group*. London, England: The Royal Society.

The United States Navy. N/A. "The US Navy Aircraft Carriers List." Washington, DC.

Thompson, James D. 1967. *Organizations in Action: Social Science Bases of Administrative Theory*. New York, NY: McGraw-Hill.

Thomsen, Jan, Raymond E. Levitt, John C. Kunz, Clifford I. Nass, and Douglas B. Fridsma. 1999. "A Trajectory for Validating Computational Emulation Models of Organizations." *Computational and Mathematical Organization Theory* 5:385-401.

Trautman, Neal. 2000. "Police Code of Silence: Facts Revealed." in *Legal Officers Section, Annual Conference, International Association of Chiefs of Police*.

Trebilcock, Michael J., and Ronald J. Daniels. 2006. "Rationales and Instruments for Government Intervention in Natural Disasters." Pp. 89-107 in *On Risk and Disaster: Lessons from Hurricane Katrina*, edited by Ronald J. Daniels, Donald F. Kettl, and Howard Kunreuther. Philadelphia, PA: University of Pennsylvania Press.

Tucker, Anita L., and Amy C. Edmondson. 2002. "When Problem Solving Prevents Organizational Learning." *Journal of Organizational Change Management* 15:122-137.

—. 2003. "Why Hospitals Don't Learn from Failures: Organizational and Psychological Dynamics That Inhibit System Change." *California Management Review* 45:55-72.

Turner, Barry A. 1976. "The Organizational and Interorganizational Development of Disasters." *Administrative Science Quarterly* 21:378-397.

Turner, Barry A., and Nick F. Pidgeon. 1997. *Man-Made Disasters*. Boston, MA: Butterworth-Heinemann.

Tversky, Amos, and Daniel Kahneman. 1974. "Judgment under Uncertainty: Heuristics and Biases." *Science* 185:3-20.

—. 1981. "The Framing of Decisions and the Psychology of Choice." *Science* 211:453-458.

—. 1992. "Advances in Prospect-Theory: Cumulative Representation of Uncertainty." *Journal of Risk and Uncertainty* 5:297-323.

United States Nuclear Regulatory Commission. 2000-2011. "List of Power Reactor Units." Washington, DC.

US Census Bureau. N/A. "Statistics about Small Business from the Census Bureau." Washington, DC.

US Chemical Safety and Hazard Investigation Board. 2007. "Investigation Report: Refinery Explosion and Fire."

Vaughan, Diane. 1996. *The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA*. Chicago, IL.: The University of Chicago Press.

—. 1997. "The Trickle-Down Effect: Policy Decisions, Risky Work, and the Challenger Tragedy." *California Management Review* 39:80-102.

Verhagen, Harko. 2001. "Simulation of the Learning Norms." *Social Science Computer Review* 19:296-306.

Vogus, Timothy J., and Theresa M. Welbourne. 2003. "Structuring for High Reliability: HR Practices and Mindful Process in Reliability-Seeking Organizations." *Journal of Organizational Behavior* 24:877-903.

Wagner, David G., and Joseph Berger. 1993. "Status Characteristics Theory: The Growth of a Paradigm." Pp. 23-63 in *Theoretical Research Program*, edited by Joseph Berger and Jr. Zeldith, Morris. Stanford, CA: Stanford University Press.

Weick, Karl E. 1979. *The Social Psychology of Organizing*. New York, NY: McGraw-Hill.

—. 1984. "Small Wins: Redefining the Scale of Social Problems." *American Psychologist* 39:40-49.

—. 1987. "Organizational Culture and High Reliability." *California Management Review* 29:112-127.

—. 1988. "Enacted Sensemaking in Crisis Situations." *Journal of Management Studies* 25:305-317.

—. 1990. "The Vulnerable System: An Analysis of the Tenerife Air Disaster." *Journal of Management* 16:571-593.

—. 1993. "The Collapse of Sensemaking in Organizations: The Mann Gulch Disaster." *Administrative Science Quarterly* 38:628-652.

—. 1995. *Sensemaking in Organizations*. Newbury Park, CA: Sage.

—. 1996. "The Nontraditional Quality of Organizational Learning." Pp. 163-174 in *Organizational Learning*, edited by Michael D. Cohen and Lee S. Sproull. Thousand Oaks, CA: Sage Publications.

Weick, Karl E., and Karlene H. Roberts. 1993. "Collective Mind in Organizations: Heedful Interrelating on Flight Decks." *Administrative Science Quarterly* 38:357-381.

Weick, Karl E., and Kathleen M. Sutcliffe. 2006. "Mindfulness and the Quality of Organizational Attention." *Organization Science* 17:514-524.

—. 2007. *Managing the Unexpected: Resilient Performance in an Age of Uncertainty*. San Francisco, CA: Jossey-Bass.

Weick, Karl E., Kathleen M. Sutcliffe, and David Obstfeld. 1999. "Organizing for High Reliability: Process of Collective Mindfulness." *Research in Organizational Behavior* 21:81-123.

—. 2005. "Organizing and the Process of Sensemaking." *Organization Science* 16:409-421.

Weick, Karl E., and Frances Westley. 1996. "Organizational Learning: Affirming an Oxymoron." Pp. 440-458 in *Handbook of Organization Studies*, edited by Stewart R. Clegg, Cynthia Hardy, and Walter R. Nord. Thousand Oaks, CA: Sage Publications.

Whyte, Glen. 1998. "Recasting Janis's Groupthink Model: The Key Role of Collective Efficacy in Decision Fiascoes." *Organizational Behavior and Human Decision Processes* 73:185-209.

Whyte, William H. 1956. *The Organization Man*. New York, NY: Simon and Schuster.

Willer, David, and Barry Markovsky. 1993. "Elementary Theory: Its Development and Research Programs." Pp. 323-363 in *Theoretical Research Programs*, edited by Joseph Berger and Jr. Zeldith, Morris. Stanford, CA: Stanford University Press.

Zhao, Bin, and Fernando Olivera. 2006. "Error Reporting in Organizations." *Academy of Management Review* 31:1012-1030.